

# LLOYDIA

*A Quarterly Journal of Biological Science*

Published by the Lloyd Library and Museum, Cincinnati, Ohio

## The Genus *Poria* in the Central Rocky Mountains and Pacific Northwest\*

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The fungi that comprise the family Polyporaceae are generally considered to be the principal agents in the decay of living trees, slash, and wood in service. Consequently, they are of particular significance to foresters. The genus *Poria*, interpreted in its broadest sense, is characterized by the development of an entirely resupinate fruiting body. This group makes up one of the largest segregates of the family Polyporaceae, and its importance in the decay of timber in our western coniferous forests has become increasingly apparent in light of recent decay studies.

Although a number of mycological collectors have been active in the Northwest, no comprehensive treatment of the genus *Poria* in that area has been prepared. Cooke (1942) made a study of 39 resupinate polypores in Oregon. Baxter (1927-1955), in a series of papers on the resupinate polypores, has reported species from the Far West, including several described as new. Other taxonomic works dealing with the Polyporaceae of this region (Murrill, 1915; Shope, 1931; Overholts, 1953) are concerned largely or wholly with pileate species. In addition to the papers mentioned, a number of lists of polypores from the northwestern United States have appeared in the literature (Weir, 1917; Murrill, 1912; Overholts, 1919; Zeller, 1922, 1929; Kauffman, 1923, 1926, 1929; Seaver and Shope, 1936; Cooke and Shaw, 1948). These include some species of *Poria*. Lists of fungi from western Canada containing species of *Poria* may be found in Bisby *et al.* (1938), Bier *et al.* (1946, 1948), Buckland (1946), Nobles (1948), Buckland *et al.* (1949), Foster and Foster (1951), Thomas and Podmore (1953), Foster *et al.* (1954), and Thomas and Thomas (1954).

The present paper recognizes 64 species of *Poria* in Montana, Idaho, Washington, Oregon, Utah, Colorado, Wyoming, British Columbia, Alberta, and Saskatchewan. Of the 64 species recognized, *P. albipel.*

\*This paper represents a portion of a thesis submitted to the faculty of the State University of New York College of Forestry, Syracuse, New York, in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June, 1954.

*lucida*, *P. albobrunnea*, *P. carbonica*, *P. carnicolor*, *P. weirii*, and *P. zonata* are not known from eastern North America. *P. prunicola*, *P. subiculosus*, *P. luteoalba*, and *P. alutacea* are previously unreported from the Northwest, and the following species are reduced to synonymy for the first time:

*Poria vicina* = *Poria corticola*  
*Poria fulvella* = *Poria bombycina*

Most of the nonstipitate polypores may produce a resupinate fruiting body if development begins on the underside of the substratum. This possibility must constantly be kept in mind in the identification of resupinate sporophores. Some species in other genera, such as *Polyporus alboluteus*, *Trametes serialis*, and *Fomes repandus*, are more commonly resupinate than pileate. For this reason, a number of species in other genera have been included in the keys.

The segregation of the species with light or bright colored context is based entirely on microscopic characters, with the shape of the basidiospores and the presence or absence of septa or clamp connections serving to divide the group into 4 major sections. The species with brown context make up the fifth section. This is a modification of the system used by Lowe (1946).

Distribution of species by states and provinces is based on collections made by the author or on herbarium specimens studied except for those given in quotation marks. These are taken from the publications cited.

The loan of specimens or herbarium privileges by the curators of the following herbaria is gratefully acknowledged: The U. S. Department of Agriculture at Beltsville, Maryland; The Smithsonian Institution; The University of Michigan; The State College of Washington; The University of Washington; The University of Idaho; Oregon State College; The Pennsylvania State University; State University of New York College of Forestry, and others who, for lack of space, cannot be listed here.

Sincere appreciation is expressed to Dr. J. L. Lowe, under whose direction this work was done.

#### KEY TO THE SECTIONS

- 1a. Context tissue distinctly brown, darkening in KOH solution.....Section 1 (species 1-9)
- 1b. Context tissue whitish to bright colored, not brown
  - 2a. Spores broadly ellipsoid to subglobose
    - 3a. Clamp connections or septa abundant in the principal context hyphae.....Section 2 (species 10-26)
    - 3b. Clamp connections and septa absent or extremely rare in the principal context hyphae.....Section 3 (species 27-31)
  - 2b. Spores cylindrical to cylindric-ellipsoid
    - 4a. Clamp connections or septa abundant in the principal context hyphae.....Section 4 (species 32-46)
    - 4b. Clamp connections and septa absent or extremely rare in the principal context hyphae.....Section 5 (species 47-64)



## SECTION 1

Context brown, darkening in KOH solution.

1a. Spores yellowish to brown

2a. Spores 4.5–7  $\mu$  long

3a. Sporophores developing on the outer surface of the bark.....resupinate *Polyporus glomeratus*

3b. Sporophores developing under outer layers of wood.....1. *P. andersoni*

2b. Spores 9–10  $\mu$  long.....2. *P. obliqua*

1b. Spores hyaline

4a. Setae and setal hyphae absent or rare

5a. Spores cylindrical, curved; only on charred conifer wood.....resupinate *Trametes carbonaria*

5b. Spores ovoid to subglobose

6a. Context and margin soft, cottony; context hyphae septate, up to 9  $\mu$  in diameter.....3. *P. subiculosa*

6b. Context woody; context hyphae rarely septate, up to 5  $\mu$  in diameter

7a. Spores ovoid, up to 5.5  $\mu$  long.....resupinate *Fomes repandus*

7b. Spores subglobose, up to 8  $\mu$  in diameter.....resupinate *Fomes robustus*

4b. Setae or setal hyphae present, usually abundant

8a. Setal hyphae abundant in the tramal tissue

9a. Spores cylindrical, curved, up to 1.5  $\mu$  wide; context tough, fissile....4. *P. ferrugineofusca*

9b. Spores ovoid, up to 3.5  $\mu$  wide; context soft-fibrous, spongy.5. *P. weirii*

8b. Setal hyphae absent or confined to the context tissue

10a. Spores cylindrical, up to 7  $\mu$  or more long

11a. Context with one or more black layers.....resupinate *Fomes nigrolimitatus*

11b. Context without black layers

12a. Spores usually curved, 1.5–2  $\mu$  wide.....resupinate *Fomes tenuis*

12b. Spores straight, 2–2.5  $\mu$  wide.....6. *P. ferrea*

10b. Spores short-cylindrical to ovoid, not over 5.5  $\mu$  long, or subglobose

13a. Setae less than 20  $\mu$  long

14a. Spores subglobose, up to 6.5  $\mu$  in diameter.resupinate *Fomes igniarius*

14b. Spores mostly ovoid, up to 5  $\mu$  long

15a. On *Prunus* only; pores 6–8 per mm.....7. *P. prunicola*

15b. On other hardwoods; pores 8–10 per mm.....8. *P. laevigata*

13b. Setae up to 40  $\mu$  or more long

16a. Spores ovoid; setae 10–14  $\mu$  in diameter

17a. On *Crataegus* only; setae infrequent; associated with a uniform white rot.....resupinate *Fomes occidentalis*

17b. On conifers; setae usually abundant; associated with a white pocket rot.....resupinate *Fomes pini*

16b. Spores short-cylindrical; setae 6–8  $\mu$  in diameter..9. *P. ferruginosa*

1. *Poria andersoni* (Ell. & Ev.) Neuman. Annual, usually developing beneath outer layers of wood; pore surface often with peglike outgrowths, the pores 1–4 per mm.; context yellowish- to dark reddish-brown, firm, the hyphae septate, some thin-walled, 2.5–4  $\mu$  in diameter, others as thick-walled setal hyphae, rare to abundant, 3–6  $\mu$  in diameter; setae ventricose, 14–20 x 5–7  $\mu$ ; spores yellowish, smooth, broadly ellipsoid, 5.5–7 x 3.5–4.5  $\mu$ . Associated with a white rot of hardwoods, in Oregon.

2. *Poria obliqua* (Pers. ex Fries) Karst. Annual, developing beneath outer layers of wood on standing trees; pores 4–6 per mm.; context bright yellowish-brown, corky, the hyphae septate, thin- to thick-walled, frequently branched, 3.5–7  $\mu$  in diameter; basidia broadly clavate, 15–18 x 11–12  $\mu$ ; setae 16–22 x 4.5–7  $\mu$ ; spores hyaline to pale brownish, broadly ellipsoid to ovoid, 9–10 x 5.5–6.5  $\mu$ . Associated with

a white rot of hardwoods, in Montana. Sterile, abortive sporophores are frequently produced by *P. obliqua* on living trees.

3. *P. subiculosa* (Peck) Cooke. Annual, soft, cottony or feltlike; pore surface yellowish-brown, the pores 1–3 per mm.; context yellowish-brown, cottony, the hyphae thin-walled, rarely branched, septate, 4–9  $\mu$  in diameter; setae none; spores hyaline, smooth, ovoid, 5–6.5 x 4–5  $\mu$ . On coniferous wood, in British Columbia.

4. *Poria ferrugineofusca* Karst. Usually annual, tough, woody; margin yellowish-brown or sometimes white; pore surface purplish-brown, the pores 4–7 per mm.; context bright yellowish-brown, fissile, the hyphae rarely branched, rarely septate, 2.5–5  $\mu$  in diameter, some pale yellowish to hyaline, thin-walled, others as dark brown, thick-walled setal hyphae, projecting from the tramal tissue up to 25  $\mu$  into the tubes; basidia narrowly clavate, 12–14 x 3–4  $\mu$ ; spores hyaline, smooth, cylindrical, curved, 4–4.5 x 1–1.5  $\mu$ . Associated with a white rot of coniferous slash, in Montana, Idaho, Washington, Wyoming, Colorado, and “Oregon”.

5. *Poria weirii* Murr. Perennial, very light in weight; pore surface pale brown with a soft, fimbriate margin, the pores 5–7 per mm.; context yellowish-brown, soft-fibrous, the hyphae of two types, some often branched, thin-walled, septate, 2.5–5.5  $\mu$  in diameter, others as thick-walled, rarely branched, nonseptate setal hyphae, 4–8.5  $\mu$  in diameter, downwardly projecting into the tubes as much as 70  $\mu$ ; spores hyaline, smooth, ovoid, 4–5 x 3–3.5  $\mu$ . Causing an important heartrot in western red cedar and also responsible for a serious root rot of other young conifers, especially Douglas fir, in Montana, Idaho, Washington, Oregon, and “British Columbia”.

6. *Poria ferrea* (Pers. ex Bourd. & Galz.) Overholts. Perennial, woody, pore surface yellowish-brown, the pores circular, 6–7 per mm.; context yellowish-brown, corky, the hyphae thick- to thin-walled, rarely branched, rarely septate, 2–4.5  $\mu$  in diameter; setae 22–29 x 6–7  $\mu$ ; spores hyaline, smooth, cylindrical, 5–7.5 x 2–2.5  $\mu$ . Associated with a white rot of hardwood slash, in Montana, Idaho, Washington, Oregon, and “British Columbia”.

7. *Poria prunicola* (Murr.) Sacc. & Trott. Perennial, woody, pore surface reddish-brown with a light yellowish-brown margin that becomes black and rimose with age, the pores circular, 6–8 per mm.; context dark reddish-brown, woody, the hyphae mostly thick- to thin-walled, rarely branched, nonseptate, 2.5–4  $\mu$  in diameter, some thin-walled, often branched, septate, 2–3  $\mu$  in diameter; setae mostly ventricose, 15–18 x 5–6  $\mu$ ; spores hyaline, smooth, ovoid to subglobose, 3.5–5 x 2.5–3.5  $\mu$ . Associated with a white rot of cherry and other members of the genus *Prunus*, in Montana.

8. *Poria laevigata* (Fries) Karst. Perennial, woody, pore surface dull reddish-brown, often becoming deeply cracked and divided into small angular sections; margin yellowish-brown, tomentose, the pores circular, 8–10 per mm.; context yellowish-brown, firm-corky, the



hyphae of two types, some thick-walled, rarely branched, nonseptate,  $2.5-5\ \mu$  in diameter, others thin-walled, often branched, septate,  $2-3.5\ \mu$  in diameter; setae mostly ventricose,  $15-19 \times 5-7\ \mu$ ; spores hyaline, smooth, ovoid,  $3-4 \times 2.5-3\ \mu$ . Associated with a white rot of hardwoods, in Montana, Idaho, Washington, "British Columbia, and Oregon".

9. *Poria ferruginosa* (Schrad. ex Fries) Karst. Annual, tough to soft-spongy; pore surface reddish-brown, often with a yellowish-brown margin, the pores circular, usually 4-6 per mm., but varying to 2-3 in some specimens; context yellowish-brown, soft-fibrous, the hyphae non-septate, of two types, some thin-walled, rarely branched,  $2-4\ \mu$  in diameter, others as thick-walled setal hyphae, tapering to a point,  $5-8\ \mu$  in diameter; tramal hyphae of the thin-walled type; setae mostly subulate,  $25-65 \times 6-8\ \mu$ ; spores hyaline, smooth, short-cylindrical,  $5-7 \times 3-3.5\ \mu$ . Associated with a white rot of hardwood slash, in Montana, Idaho, Washington, "British Columbia, and Oregon".

## SECTION 2

Context tissue whitish to bright-colored; spores broadly ellipsoid to subglobose; clamp connections or septa abundant in the principal context hyphae.

- 1a. Principal context hyphae septate, not clamped
  - 2a. Spores yellowish; sporophores drying brownish to black. 10. *P. incrassata*
  - 2b. Spores hyaline; sporophores drying whitish, pinkish, yellowish, or blackish
  - 3a. Sporophores perennial
    - 4a. Pinkish when fresh and on drying; associated with a uniform white rot.....11. *P. nigrescens*
    - 4b. White when fresh, drying pale pinkish-brown; associated with a white pocket rot.....12. *P. undata*
  - 3b. Sporophores annual, white when fresh
    - 5a. Conspicuous cystidia present
      - 6a. Sporophores soon becoming irpiciform.....resupinate *Polyporus tulipiferae*
      - 6b. Sporophores poroid
        - 7a. On western redcedar only.....resupinate *Polyporus cuneatus*
        - 7b. On hardwoods or rarely on conifers
          - 8a. Pores 5-7 per mm.; spores  $3-4 \times 2-2.5\ \mu$ .....13. *P. similis*
          - 8b. Pores 2-4 per mm.; spores  $5-7 \times 3-5\ \mu$ .....14. *P. corticola*
      - 5b. Cystidia absent
        - 9a. Sporophores becoming lemon yellow to pinkish; hyphae not more than  $5\ \mu$  in diameter.....15. *P. terrestris*
        - 9b. Sporophores remaining white or turning reddish or blackish; hyphae often over  $5\ \mu$  in diameter
          - 10a. Sporophores turning blood red on bruising, drying grayish to blackish; pores 8-10 per mm.....16. *P. sanguinolenta*
          - 10b. Sporophores drying white to cream; pores 1-3 per mm.....17. *P. ambigua*
  - 1b. Principal context hyphae with clamp connections
    - 11a. Margin usually conspicuously rhizomorphic
      - 12a. Rhizomorphs white or ivory
        - 13a. Spores echinulate.....18. *P. candidissima*
        - 13b. Spores smooth
          - 14a. Spores broadly ellipsoid,  $5-8 \times 3-4\ \mu$ .....19. *P. vaillantii*
          - 14b. Spores ovoid to subglobose,  $2.5-4 \times 2-2.5\ \mu$ .....20. *P. myceliosa*
      - 12b. Rhizomorphs yellow.....21. *P. albolutescens*
    - 11b. Margin not rhizomorphic
      - 15a. Sporophores yellowish to pinkish-brown, very soft...22. *P. bombycina*
      - 15b. Sporophores white to tan, not brightly colored

- 16a. Spores broadly ellipsoid, up to  $7\ \mu$  long  
 17a. Pores 3-5 per mm.; clamp connections minute.....23. *P. versipora*  
 17b. Pores 1-3 per mm.; clamp connections large.....24. *P. aneirina*  
 16b. Spores ovoid to subglobose, up to  $5.5\ \mu$  long  
 18a. Spores  $2.5-3.5 \times 2-2.5\ \mu$ ; sporophores soft.....25. *P. mollusca*  
 18b. Spores  $4.5-5.5 \times 3-4\ \mu$ ; sporophores crisp, drying firm.....26. *P. albipellucida*

10. *Poria incrassata* (Berk. & Curt.) Burt. Annual, whitish when fresh, becoming grayish-brown to black on drying, the pores 2-3 per mm.; context drying buff, soft-fibrous, the hyphae hyaline, septate, thin-walled,  $3.5-4.5\ \mu$  in diameter; spores yellowish, smooth, broadly ellipsoid,  $7-10.5 \times 4.5-6.5\ \mu$ . Associated with a brown cubical rot of coniferous and hardwood structural timbers, in Oregon and Idaho.

11. *Poria nigrescens* Bres. Perennial, tough, crisp when fresh, drying rigid and horny; pore surface flesh-colored to pinkish-brown, the pores 5-7 per mm.; context pinkish-buff, the hyphae hyaline, thick to thin-walled, septate,  $3-8.5\ \mu$  in diameter; spores hyaline, smooth, ovoid to subglobose,  $4-6 \times 3.5-5\ \mu$ . Associated with a white rot of coniferous and hardwood slash and, according to Buckland *et al.* (1949), causing a heartrot of living hemlocks in British Columbia; also in Idaho and Washington.

12. *Poria undata* (Pers.) Bres. Annual, crisp-cartilaginous when fresh, drying hard and horny; pore surface watery-white when fresh, becoming pale brownish-pink on drying, the pores angular, 4-5 per mm.; context white when fresh, pinkish when dried, the hyphae hyaline, thin to thick-walled, septate,  $2-3.5\ \mu$  in diameter; spores hyaline, smooth, ovoid to subglobose,  $4-5.5 \times 3-4.5\ \mu$ . Associated with a white pocket rot of hardwood and coniferous slash, in British Columbia and Idaho.

13. *Poria similis* Bres. Annual, soft; pore surface white to ivory, the pores 4-6 per mm.; context white, soft, the hyphae hyaline, thin-walled, septate,  $2-3.5\ \mu$  in diameter; cystidia abundant, varying from completely to only capitately incrustated, partially or entirely imbedded,  $16-30 \times 6-12\ \mu$ ; spores hyaline, smooth, ovoid,  $3-4 \times 2-2.5\ \mu$ . Associated with a white rot of cottonwood logs, in Montana, Idaho, Washington, and Oregon.

14. *Poria corticola* (Fries) Cooke. Annual or rarely perennial, tough; pore surface cream-colored to pale tan, the pores 2-4 per mm.; context ivory, soft-fibrous, the hyphae hyaline, thin-walled, septate, often partially incrustated,  $2-4\ \mu$  in diameter; cystidia entirely or capitately incrustated,  $17-25 \times 5-7\ \mu$ ; spores hyaline, smooth, broadly ellipsoid to ovoid,  $5-7 \times 3-5\ \mu$ . Associated with a white rot, usually of hardwood slash, but occasionally on coniferous wood, in British Columbia, Montana, Idaho, Colorado, "Alberta, Saskatchewan, Washington, and Oregon".

15. *Poria terrestris* Bres. Annual, soft; margin sometimes rhizomorphic; pore surface becoming lemon yellow or pinkish, the pores 2-4 per mm.; context yellowish, soft-fibrous, the hyphae hyaline, thin-



walled, septate,  $2-5\ \mu$  in diameter; spores hyaline, smooth, subglobose to ovoid,  $3.5-4.5 \times 2.5-3.5\ \mu$ . Found in and under rotten coniferous logs, in Montana, "Idaho, and Washington".

16. *Poria sanguinolenta* (Alb. & Schw. ex Fries) Cooke. Annual or reviving a second time, cartilaginous and crisp, drying rigid; pore surface white when fresh, quickly showing bright rusty red blotches after collecting and becoming grayish to blackish on drying, the pores 6-8 per mm.; context white when fresh, pale tan when dried, the hyphae hyaline, not easily separable, thick- to thin-walled, septate,  $3.5-6.5\ \mu$  in diameter; basidia broadly clavate,  $12-14 \times 7-9\ \mu$ ; spores hyaline, smooth, ovoid to subglobose,  $5-6 \times 4-5\ \mu$ . Associated with a brown rot, usually of coniferous wood, in Montana, Idaho, Washington, "British Columbia, and Oregon".

17. *Poria ambigua* Bres. Annual, soft when fresh, firm when dried; pore surface white, the pores angular, 1-3 per mm.; context whitish, soft-fibrous, the hyphae hyaline, thin-walled, septate, 3-8  $\mu$  in diameter; spores hyaline, smooth, broadly ellipsoid,  $4.5-6 \times 2.5-3\ \mu$ . Associated with a white rot of hardwood slash, in Washington, "British Columbia, Alberta, and Oregon".

18. *Poria candidissima* (Schw.) Cooke. Annual, very soft and fragile, margin rhizomorphic; pore surface white, the pores angular, 2-4 per mm.; context white, soft, the hyphae hyaline, thin-walled, abundantly clamped and septate,  $2.5-4\ \mu$  in diameter; spores hyaline, echinulate, ovoid to subglobose,  $3.5-4 \times 2-3.5\ \mu$ . On rotten wood in Montana, Idaho, Washington, Oregon, and "British Columbia".

19. *Poria vaillantii* (DC ex Fries) Cooke. Annual, soft-fibrous; margin usually rhizomorphic; pore surface white to ivory, the pores 2-4 per mm.; context white, soft, the hyphae variable, hyaline, thin-walled, some clamped,  $2-4\ \mu$  in diameter, others nonseptate,  $1-1.5\ \mu$  in diameter; spores hyaline, smooth, broadly ellipsoid,  $5-8 \times 3-4\ \mu$ . Associated with a brown cubical rot of coniferous slash and structural timbers, in Idaho, Washington, and "British Columbia".

20. *Poria myceliosa* Peck. Annual, soft, margin rhizomorphic, pore surface ivory to pale tan, the pores 1-4 per mm.; context ivory, soft, the hyphae hyaline, thin-walled, abundantly clamped,  $2.5-5.5\ \mu$  in diameter; spores hyaline, smooth, ovoid to subglobose,  $2.5-4 \times 2-2.5\ \mu$ . On rotten coniferous wood, in Montana, Idaho, Wyoming, "British Columbia, and Oregon".

21. *Poria albolutescens* (Rom.) Egeland. Annual, soft; margin with yellow rhizomorphs; pore surface pale yellow, the pores angular, 2-4 per mm.; context ivory to pale yellow, soft, the hyphae hyaline, thin-walled, abundantly clamped,  $2.5-4\ \mu$  in diameter; spores hyaline, smooth, broadly ellipsoid to ovoid or subglobose,  $3.5-5 \times 2.5-3\ \mu$ . Associated with a brown rot of coniferous slash, in British Columbia, Idaho, Washington, Colorado, and "Oregon".

22. *Poria bombycina* (Fries) Cooke. Annual, soft, fibrous; pore surface pale yellowish to pinkish-brown, the pores 2-3 per mm.; context

pinkish-tan, soft, the hyphae hyaline, loosely interwoven, thin-walled, abundantly clamped,  $2.5\text{--}5\ \mu$  in diameter; spores hyaline, smooth, broadly ellipsoid,  $4.5\text{--}8 \times 3\text{--}5\ \mu$ . Associated with a brown rot of coniferous slash, in Montana, Idaho, and Washington.

23. *Poria versipora* (Pers.) Rom. Annual, tough, drying corky; pore surface whitish to cream, drying to buff, the pores  $3\text{--}5$  per mm.; context cream to buff, corky, the hyphae hyaline, with abundant minute clamps,  $2.5\text{--}4\ \mu$  in diameter; cystidioles usually present,  $11\text{--}12 \times 3\text{--}4\ \mu$ ; terminally inflated hyphae often present in the hymenial and tramal tissues; spores hyaline, smooth, broadly ellipsoid,  $5\text{--}7 \times 3\text{--}4\ \mu$ . Associated with a white rot of hardwood and coniferous slash, in British Columbia, Idaho, Washington, Oregon, and "Montana".

24. *Poria aneirina* (Sommerf.) Cooke. Annual, tough; pore surface cream to tan, the pores angular,  $1\text{--}3$  per mm.; context whitish, tough, the hyphae hyaline, often branched, thin-walled, abundantly clamped,  $2\text{--}5.5\ \mu$  in diameter; spores hyaline, smooth, broadly ellipsoid, conspicuously apiculate,  $5\text{--}6 \times 3\text{--}3.5\ \mu$ . Associated with a white rot of cottonwood slash, in Montana, Idaho, and "Wyoming".

25. *Poria mollusca* (Pers. ex Fries). Annual, fragile; pore surface whitish to cream, the pores  $5\text{--}7$  per mm.; context ivory, soft, the hyphae hyaline, thin-walled, abundantly clamped,  $2\text{--}4\ \mu$  in diameter; spores hyaline, smooth, ovoid to subglobose,  $2.5\text{--}3.5 \times 2\text{--}2.5\ \mu$ . On coniferous and hardwood slash, in Montana, Washington, "British Columbia, Idaho, and Oregon".

26. *Poria albipellucida* Baxter. Annual, crisp when fresh, drying firm; pore surface watery-white, the pores  $2\text{--}5$  per mm.; context white, the hyphae hyaline, closely interwoven, thin-walled, clamped,  $2.5\text{--}4\ \mu$  in diameter; cystidioles abundant, imbedded,  $15\text{--}17 \times 5\text{--}5.5\ \mu$ ; spores hyaline, smooth, ovoid to subglobose,  $4.5\text{--}5.5 \times 3\text{--}4\ \mu$ . Associated with a white rot of coniferous slash and, according to Buckland (1946) causing a serious butt rot of living western redcedar, in British Columbia, Montana, Idaho, Washington, and "Oregon".

### SECTION 3

Context tissue whitish to bright colored; spores subglobose to broadly ellipsoid; clamp connections and septa absent or extremely rare in the principal context hyphae

- 1a. Hymenium at first enclosed within papillae which rupture apically to form tubes; margin rhizomorphic. . . . . 27. *P. fimbriata*
- 1b. Hymenium exposed throughout development; rhizomorphs absent
  - 2a. Spores truncate at one end, at least in part
    - 3a. Hyphae slender, much branched,  $1\text{--}3\ \mu$  in diameter; pores  $5\text{--}6$  per mm. . . . . 28. *P. unita*
    - 3b. Hyphae rarely branched,  $2.5\text{--}6\ \mu$  in diameter; pores  $3\text{--}5\ \mu$  per mm. . . . . 29. *P. tenuis*
  - 2b. Spores rounded at both ends
    - 4a. Sporophores annual, cartilaginous; spores  $4\text{--}5 \times 3\text{--}3.5\ \mu$ . . . . . resupinate *Polyporus semisupinus*
    - 4b. Sporophores perennial, waxy to tough-corky; spores larger
      - 5a. Spores subglobose,  $4\text{--}5 \times 3\text{--}4.5\ \mu$ ; pore surface whitish, glancing. . . . . resupinate *Fomes annosus*
      - 5b. Spores broadly ellipsoid to ovoid,  $4\text{--}6\ \mu$  long; pore surface usually



- yellowish or cream  
 6a. Tissue bitter, cheesy or friable when dry; associated with a brown rot.....30. *P. crassa*  
 6b. Tissue resinous, tough, corky when dry; associated with a white rot.....31. *P. subacida*

27. *Poria fimbriata* (Pers. ex Fries) Lloyd. Annual, soft; margin conspicuously rhizomorphic; pore surface ivory or cinereous, the pores forming by the development of an apical pore in isolated papillae which later became fused to form a typical tube layer, 3-5 per mm.; context whitish, soft, the hyphae thick- to thin-walled, nonseptate, with occasional swollen knobs, 1.5-2.5  $\mu$  in diameter; basidia narrowly clavate, 18-20 x 5-6  $\mu$ ; spores hyaline, smooth, short-cylindrical to broadly ellipsoid, 4-5.5 x 2-3  $\mu$ . Associated with a spongy white rot of coniferous and hardwood slash, in Montana, "Idaho, and Washington".

28. *Poria unita* (Pers.) Karst. Perennial, tough; pore surface ivory to pale lemon yellow, the pores 5-6 per mm.; context cream-colored, corky, the hyphae hyaline, thick-walled; much branched, nonseptate, 1-3  $\mu$  in diameter; cystidioles present, fusoid, 10-11 x 5-6  $\mu$ ; spores hyaline, smooth, broadly ellipsoid to short-oblong, mostly truncate at one end, 5-7.5 x 3-4  $\mu$ . Associated with a white rot of hardwood slash, rarely on coniferous wood, in Montana, Idaho, "Washington, and Oregon".

29. *Poria tenuis* (Schw.) Cooke. Perennial, cheesy when fresh, tough when dry; pore surface cream-colored or tan on drying, the pores 3-5 per mm.; context white to ivory, the hyphae hyaline, of two types, some thick-walled, nonseptate, rarely branched, 2.5-6  $\mu$  in diameter, others thin-walled, rarely clamped, 2-4  $\mu$  in diameter; fusoid cystidioles present; spores hyaline, smooth, broadly ellipsoid to ovoid, mostly truncate at one end, 5-6.5 x 3-4  $\mu$ . Associated with a white rot of hardwood slash, in Montana.

30. *Poria crassa* (Karst.) Sacc. Perennial, soft and waxy when fresh, drying crumbly to tough-cheesy; taste bitter; pore surface whitish to cream, the pores 5-7 per mm.; context whitish to ivory, crumbly, the hyphae hyaline, thin- to thick-walled, rarely clamped, 2.5-5  $\mu$  in diameter; fusoid cystidioles present, 11-12 x 4-5  $\mu$ ; spores hyaline, smooth, broadly ellipsoid to ovoid, 4-6 x 2.5-3.5  $\mu$ . Associated with a brown rot of coniferous slash, in Washington, "British Columbia, and Oregon".

31. *Poria subacida* (Peck) Sacc. Perennial, tough; pore surface ivory, yellowish, or tan, the pores 3-5 per mm.; context tan, the hyphae thin- to thick-walled, nonseptate, of two types, some rarely branched, 2.5-6  $\mu$  in diameter, others often branched, 1-1.5  $\mu$  in diameter; systidioles present, often incrustated, 13-17 x 5-6  $\mu$ ; spores hyaline, smooth, broadly ellipsoid to ovoid, 4.5-6.5 x 3.5-5  $\mu$ . Causing a white rot of coniferous and hardwood slash and an important butt and root rot of living conifers, in Montana, Idaho, Washington, Oregon, and "British Columbia".

## SECTION 4

Sporophores white to brightly colored; spores cylindrical to cylindric-ellipsoid; clamp connections or septa abundant in the principal context hyphae.

- 1a. Principal context hyphae septate, clamp connections absent
  - 2a. Pores 1 mm. or more in diameter; large cystidia abundant; pore surface reddish-orange.....resupinate *Polyporus alboluteus*
  - 2b. Pores usually less than 1 mm. in diameter; cystidia absent; pore surface variously colored
    - 3a. Spores 5-9  $\mu$  long
      - 4a. Sporophores tough, often associated with a sclerotium; pore surface whitish to tan.....32. *P. cocos*
      - 4b. Sporophores soft; pore surface white to pinkish, pale orange, or flesh-colored.....33. *P. reticulata*
      - 4c. Sporophores soft; pore surface purplish.....34. *P. purpurea*
    - 3b. Spores 3.5-5  $\mu$  long
      - 5a. Context hyphae often inflated at the septa, up to 7  $\mu$  or more in diameter
        - 6a. Pore surface cream, pinkish, or orange.....35. *P. viridans*
        - 6b. Pore surface grayish or pale tan.....36. *P. griseoalba*
      - 5b. Context hyphae uniform in diameter, up to 5  $\mu$  wide
        - 7a. Context and marginal tissue white; tube layer dark purple; pores 3-5 per mm.....37. *P. taxicola*
        - 7b. Context pale pinkish-tan; tube layer dark reddish-orange; pores 7-9 per mm.....38. *P. spissa*
        - 7c. Context whitish; tube layer whitish, pinkish or tan; pores 3-5 per mm.....39. *P. semitincta*
  - 1b. Principal context hyphae with abundant clamp connections
    - 8a. Pore surface salmon pink.....40. *P. carnicolor*
    - 8b. Pore surface becoming dark purplish.....resupinate *Polyporus dichrous*
    - 8c. Pore surface whitish, sometimes drying straw-colored or pale yellowish
      - 9a. Incrusted cystidia present; taste bitter.....41. *P. asiatica*
      - 9b. Cystidia lacking; taste mild
        - 10a. Spores over 5  $\mu$  long and 2  $\mu$  wide
          - 11a. Spores 8-11  $\mu$  long, straight.....42. *P. mappa*
          - 11b. Spores 5.5-9  $\mu$  long, often curved.....43. *P. crustulina*
        - 10b. Spores 3-5 x 1-1.5  $\mu$ 
          - 12a. Sporophores cheesy; pore surface with greenish or olivaceous tints.....44. *P. pannocincta*
          - 12b. Sporophores fibrous or corky; pore surface white to cream
            - 13a. Pores 2-3 per mm.
              - 14a. Context corky; context hyphae 4-7  $\mu$  in diameter.....resupinate *Polyporus undosus*
              - 14b. Context soft-fibrous; context hyphae 2-3.5  $\mu$  in diameter.....45. *P. vaporaria*
            - 13b. Pores 4-7 per mm.
              - 15a. Context homogeneous; cystidioles absent.....resupinate *Polyporus perdelicatus*
              - 15b. Context with a darker gelatinous layer; cystidioles usually present.....46. *P. vulgaris*

32. *Poria cocos* (Schw.) Wolf. Annual, sometimes developing from a sclerotium, tough when fresh, drying hard and brittle; pore surface ivory to tan, the pores 1-3 per mm.; context ivory, tan, or rarely dark brown, the hyphae hyaline to pale brownish, thin- to thick-walled, often branched, septate, 2-14  $\mu$  in diameter; spores hyaline, smooth, cylindrical, 6-8 x 2.5-3  $\mu$ . Causing a brown cubical butt and root rot of living conifers and hardwoods, usually associated with sclerotia, but also fruiting on coniferous logs, in Idaho, "Saskatchewan, Washington, and Oregon".



33. *Poria reticulata* (Fries) Cooke. Annual, fragile; tubes arising as shallow isolated cupules in the marginal tissue; pore surface white to pinkish, pale orange, or flesh-colored, the pores 3-4 per mm.; context often very thin and weblike, the hyphae hyaline, thin-walled, often branched, septate, loosely interwoven, 3-5  $\mu$  in diameter; spores hyaline, smooth, cylindrical, some slightly curved, 6-9.5 x 2-3  $\mu$ . Found on well-decayed wood, in British Columbia and "Alberta".

34. *Poria purpurea* (Fries) Cooke. Annual, soft; pore surface light- to dark purplish, the pores 3-4 per mm.; context pale purplish-brown to whitish, soft, the hyphae hyaline, thin-walled, often branched, septate, very loosely interwoven, 2.5-5.5  $\mu$  in diameter; spores hyaline, smooth, cylindrical, curved, 5-9 x 2-2.5  $\mu$ . Associated with a white rot of hardwood slash, in Montana, Idaho, Washington, "British Columbia, Alberta, Oregon, and Colorado".

35. *Poria viridans* (Berk. & Br.) Cooke. Annual, soft; pore surface cream-colored, pinkish, or orange-tan, the pores 3-5 per mm.; context ivory to tan, soft, the hyphae hyaline, thin-walled, often branched, septate, often swollen at the septa, 4-7  $\mu$  in diameter; spores hyaline, smooth, short-cylindrical, often slightly curved, 3.5-4 x 1.5-2  $\mu$ . Associated with a decay of hardwood slash, in Montana.

36. *Poria griseoalba* (Peck) Sacc. Annual, soft, fragile, margin cupulate; pore surface grayish to pale tan, the pores circular, arising as isolated cupules in the marginal tissue, 3-4 per mm.; context very thin and soft, whitish, the hyphae hyaline, loosely arranged, thin-walled, often branched, septate, often swollen at the septa, 4-10  $\mu$  in diameter; spores hyaline, smooth, short-cylindrical, some slightly curved, 3.5-5 x 2-2.5  $\mu$ . Associated with a white rot of hardwood and coniferous slash, in British Columbia and "Oregon".

37. *Poria taxicola* (Pers.) Bres. Annual, soft; margin white, fimbriate; pore surface and tube layer dark purplish, the pores 4-5 per mm.; context white, soft, the hyphae hyaline, thin-walled, often branched, septate, often partially incrustated, 2.5-5  $\mu$  in diameter; cystidioles 11-13 x 2.5-4  $\mu$ ; spores hyaline, smooth, cylindrical, curved, 3.5-4 x 1-1.5  $\mu$ . Associated with a white rot of coniferous slash, in Idaho, Washington, "British Columbia, Alberta, Montana, and Oregon".

38. *Poria spissa* (Schw.) Cooke. Annual, soft, cheesy when fresh; pore surface and tube layer dark reddish-orange, cracking on drying, usually glistening, the pores 7-9 per mm.; context pale pinkish-tan, soft, the hyphae hyaline, thin-walled, often branched, septate, 2.5-3.5  $\mu$  in diameter; spores hyaline, smooth, cylindrical, curved, 4-5 x 1.5-2  $\mu$ . Associated with a white rot of hardwood slash, in Washington and Oregon.

39. *Poria semitincta* (Peck) Cooke. Annual, fragile; pore surface and tube layer whitish to pale pinkish or tan, the pores 3-4 per mm.; context whitish, soft, the hyphae hyaline, often branched, thin-walled, septate, 2.5-4.5  $\mu$  in diameter; spores hyaline, smooth, short-cylindrical,

3.5–4.5 x 1.5–2  $\mu$ . Associated with a white rot of hardwood and coniferous slash, in British Columbia.

40. *Poria carnicolor* Baxter. Annual; pore surface salmon-pink, the pores 3–4 per mm.; context whitish or pale salmon-pink, the hyphae hyaline, thick- to thin-walled, often branched, clamped, 2–4.5  $\mu$  in diameter; spores hyaline, smooth, cylindrical, 5.57 x 2.5–3  $\mu$ . Associated with a brown cubical rot of coniferous slash, in Montana, Washington, and "Idaho".

41. *Poria asiatica* (Pilát) Overh. Annual, drying corky; taste bitter; pore surface white to yellowish, the pores 2–4 per mm.; context whitish, the hyphae hyaline, thin- to thick-walled, often branched, frequently clamped, 2.5–4  $\mu$  in diameter; cystidia mostly ventricose, capitately incrustated, 14–26 x 4–7  $\mu$ ; spores hyaline, smooth, short-cylindrical, often curved, 3.5–5 x 2–2.5  $\mu$ . Causing a brown cubical rot of coniferous wood; especially a heartrot of living western redcedar (Buckland, 1946), in Montana, Idaho, "British Columbia, Washington, and Oregon".

42. *Poria mappa* Overh. & Lowe. Annual, often extremely thin with practically no context, soft; pore surface white to buff, the pores 3–4 per mm.; context white, soft, the hyphae hyaline, thin- to thick-walled, often branched, abundantly clamped, 2.5–3  $\mu$  in diameter; spores hyaline, smooth, cylindrical, 8–11 x 2–3  $\mu$ . Associated with a very weak decay of coniferous wood, in British Columbia and Idaho.

43. *Poria crustulina* Bres. Annual, tough; pore surface cream-colored to buff, the pores 3–4 per mm.; context white, felty-tough, the hyphae hyaline, thin-walled, rarely branched, abundantly clamped, 3–5  $\mu$  in diameter; spores hyaline, smooth, cylindrical, often curved, 5.5–9 x 3–3.5  $\mu$ . Associated with a white rot of coniferous slash, in British Columbia, Montana, Colorado, "Idaho, Washington, and Utah".

44. *Poria pannocincta* (Rom.) Lowe. Annual, cheesy; pore surface ivory, sometimes becoming greenish or olivaceous, glistening, the pores 6–8 per mm.; context whitish, soft, with a darker resinous layer near the tubes, the hyphae hyaline, frequently branched, thin-walled, abundantly clamped, occasionally septate, 3–7  $\mu$  in diameter; spores hyaline, smooth, cylindrical, curved, 3.5–4 x 0.7–1  $\mu$ . Associated with a white rot of hardwood slash, commonly on cottonwood, in Montana, "British Columbia, and Idaho".

45. *Poria vaporaria* (Pers. ex Fries) Cooke. Annual, soft-fibrous when dried; pore surface cream to pale tan, the pores 2–3 per mm.; context whitish to tan, soft-fibrous, the hyphae hyaline, thin- to thick-walled, often branched, clamped, 2–3.5  $\mu$  in diameter; cystidioles often present, 12–16 x 3–4  $\mu$ ; spores hyaline, smooth, cylindrical, curved, 4–5 x 1–1.5  $\mu$ . Associated with a brown rot of coniferous slash, in British Columbia, Montana, Washington, "Idaho, and Oregon".

46. *Poria vulgaris* (Fries) Cooke. Annual, soft-fibrous; pore surface white to ivory, the pores 5–7 per mm.; context white, with a darker



gelatinous layer, soft, the hyphae hyaline, thin- to thick-walled, occasionally branched, clamped,  $2-6\ \mu$  in diameter; inconspicuous cystidioles often present, fusiform,  $10-12 \times 3-4\ \mu$ ; spores hyaline, smooth, cylindrical, curved,  $3-5 \times 1-1.5\ \mu$ . Associated with a decay of coniferous slash, in British Columbia, Montana, Washington, "Alberta, Idaho, Oregon, and Utah".

## SECTION 5

Sporophores white to brightly colored; spores cylindrical to cylindric-ellipsoid; clamp connections and septa absent or extremely rare in the principal context hyphae.

- 1a. Cystidia conspicuous, usually incrustated
  - 2a. Pore surface bright colored
    - 3a. Pore surface violaceous.....resupinate *Polyporus abietinus*
    - 3b. Pore surface pinkish
      - 4a. Pores 3-4 per mm.; spores  $1-1.5\ \mu$  wide; on coniferous wood.....47. *P. rixosa*
      - 4b. Pores 5-7 per mm.; spores  $2-2.5\ \mu$  wide; on hardwoods.....48. *P. eupora*
  - 2b. Pore surface whitish to cream or pale tan
    - 5a. Pores 1-3 per mm.....49. *P. zonata*
    - 5b. Pores 4-5 per mm.....50. *P. luteoalba*
- 1b. Cystidia absent
  - 6a. Pore surface brightly colored
    - 7a. Basidia cruciately septate; pore surface pinkish-brown when fresh.....51. *Aporpium caryae*
    - 7b. Basidia one-celled; pore surface not pinkish-brown when fresh.....
      - 8a. Pore surface yellow at first, sometimes fading to cream.....52. *P. xantha*
      - 8b. Pore surface flesh-colored to orange
        - 9a. Pore surface drying pinkish-brown to blackish; spores  $4-6 \times 2-2.5\ \mu$ .....53. *P. rubens*
        - 9b. Pore surface drying flesh colored to reddish-orange; spores  $3-5 \times 1\ \mu$ .....resupinate *Polyporus amorphus*
  - 6b. Pore surface white to cream or tan
    - 10a. Pores mostly 2-4 per mm.
      - 11a. Principal context hyphae up to  $2-3.5\ \mu$  in diameter....54. *P. sinuosa*
      - 11b. Principal context hyphae up to  $6-9\ \mu$  in diameter
        - 12a. Principal context hyphae  $5-9\ \mu$  in diameter; spores  $5-5.5\ \mu$  long; tube layer up to 10 mm. thick.....55. *P. carbonica*
        - 12b. Principal context hyphae  $2.5-6\ \mu$  in diameter; spores  $4-5\ \mu$  long; tube layer up to 3 mm. thick.....56. *P. monticola*
        - 12c. Principal context hyphae  $2.5-5\ \mu$  in diameter; spores up to  $9\ \mu$  long; tube layer up to 5 mm. thick.....resupinate *Trametes serialis*
    - 10b. Pores mostly 4-9 per mm.
      - 13a. Spores usually lunate.....57. *P. lenis*
      - 13b. Spores allantoid or straight
        - 14a. Taste very bitter
          - 15a. Spores  $3.5-5\ \mu$  long.....58. *P. oleagina*
          - 15b. Spores  $8-10\ \mu$  long.....59. *P. stenospora*
        - 14b. Taste mild or mildly resinous
          - 16a. Context dark brown near the substratum.....60. *P. albobrunnea*
          - 16b. Context homogeneous, white to cream
            - 17a. Margin rhizomorphic.....61. *P. alutacea*
            - 17b. Margin not rhizomorphic
              - 18a. Context hyphae  $3-8\ \mu$  in diameter; pore surface becoming cinereous.....62. *P. cinerascens*
              - 18b. Context hyphae  $2.5-5\ \mu$  in diameter; pore surface ivory to pale buff
                - 19a. Sporophores annual; margin cream to pale buff; pore surface often extensively cracked.....63. *P. subincarnata*
                - 19b. Sporophores perennial; margin becoming reddish-brown; pore surface often with shallow circular depressions.....64. *P. sitchensis*

47. *Poria rixosa* Karst. Annual, tough; pore surface light brownish-pink, the pores 3-4 per mm.; context light pinkish-buff, soft-corky, the hyphae hyaline, thin- or thick-walled, often branched, closely interwoven, nonseptate, 2-3.5  $\mu$  in diameter; hyphal pegs often present; cystidia frequent to rare, incrusting, clavate, 28-40 x 9-11  $\mu$ ; spores hyaline, smooth, cylindrical, slightly curved, 3-5 x 1-1.5  $\mu$ . Associated with a white rot of coniferous slash, in British Columbia, Montana, Idaho, "Alberta, and Washington".

48. *Poria eupora* (Karst.) Cooke. Annual, tough; pore surface flesh-colored to pinkish, the pores 5-7 per mm.; context ivory to pale flesh-colored, corky, the hyphae hyaline, thick- to thin-walled, rarely branched, nonseptate, 2-4  $\mu$  in diameter; cystidia usually abundant, incrusting, narrowly clavate, thick-walled, 17-32 x 4-9  $\mu$ ; spores hyaline, smooth, cylindric-ellipsoid, 4-5 x 2-2.5  $\mu$ . Associated with a white rot of hardwood slash and occasionally on coniferous wood, in Idaho and Washington.

49. *Poria zonata* Bres. Annual, drying rigid; pore surface ivory to plan tan, the pores angular, 1-3 per mm.; context ivory, corky, the hyphae hyaline, mostly thick-walled, rarely branched, rarely clamped, 2.5-7  $\mu$  in diameter, some thin-walled, rarely branched, clamped, 2-4  $\mu$  in diameter; cystidia abundant, narrowly conical, incrusting, 40-50 x 9-11  $\mu$ ; spores hyaline, smooth, cylindrical, mostly curved, 5-7.5 x 2-2.5  $\mu$ . Associated with a brown rot of coniferous slash, in Idaho.

50. *Poria luteoalba* (Karst.) Sacc. Annual, tough; pore surface cream to pale tan, the pores 4-5 per mm.; context cream or pale tan, corky, the hyphae hyaline, thin- to thick-walled, occasionally branched, nonseptate, mostly 2-3  $\mu$  in diameter, a few 8-12  $\mu$  in diameter; cystidia abundant to rare, incrusting, 9-14  $\mu$  in diameter, imbedded or projecting up to 30  $\mu$ , usually most abundant near the edges of the dissepiments; hyphal pegs often present; spores hyaline, smooth, cylindrical, usually curved, 4-5.5 x 1.5-2  $\mu$ . Associated with a brown rot of coniferous wood, in Montana, Idaho, and Oregon.

51. *Aporeium caryae* (Schw.) Teixeira & Rogers. (*Poria canescens* Karst.) Annual, corky; pore surface pale pinkish-brown, often spotted with light reddish-brown when bruised, the pores 3-5 per mm.; context thin, buff, the hyphae hyaline, mostly thick-walled, rarely branched, nonseptate, 2-3.5  $\mu$  in diameter, some thin-walled, not easily separable; hyphal pegs usually present; basidia cruciately septate; spores hyaline, smooth, cylindrical, often curved, 4.5-6 x 2-2.5  $\mu$ . Associated with a white rot of hardwood slash, in Idaho and Washington. Although this fungus has the macroscopic characteristics of a polypore, Teixeira & Rogers (1955) have recently pointed out that the cruciately septate basidia place it in the Tremellaceae.

52. *Poria xantha* (Fries) Cooke. Annual, crumbly or chalky; taste very bitter; pore surface sulfur yellow or fading to ivory, often extensively cracked, the pores 5-7 per mm.; context whitish to ivory, chalky, the hyphae hyaline, thick-walled, rarely branched, nonseptate,



2–6.5  $\mu$  in diameter; cystidioles abundant, fusoid; spores hyaline, smooth, cylindrical, curved, 3.5–5 x 1–1.5  $\mu$ . Associated with a brown rot of hardwood and coniferous slash and structural timbers, in Montana, Idaho, Washington, and “Alberta”.

53. *Poria rubens* Overh. & Lowe. Annual, soft and waxy when fresh, cheesy to brittle when dried; pore surface orange when fresh, purplish-brown or vinaceous when dry, often becoming blackish, the pores angular, 2–3 per mm.; context drying purplish-brown, cheesy, the hyphae hyaline, mostly thick-walled, rarely to often branched, rarely clamped, 2.5–6  $\mu$  in diameter, some thin-walled, rarely branched, clamped, 2–3  $\mu$  in diameter; spores hyaline, smooth, short-cylindrical, 4–5 x 2–2.5  $\mu$ . On dead coniferous wood, in Idaho and “British Columbia”.

54. *Poria sinuosa* (Fries) Cooke. Annual, tough-corky; taste resinously bitter; pore surface ivory to tan, the pores 2–4 per mm.; dissepiments becoming deeply lacerate; context whitish, corky, the hyphae hyaline, thick-walled, nonseptate, rarely branched, 2–3.5  $\mu$  in diameter; spores hyaline, smooth, cylindrical, mostly curved, 4–5.5 x 1.5–2  $\mu$ . Associated with a brown cubical rot of coniferous slash, in British Columbia, Montana, Idaho, “Alberta, Washington, and Oregon”.

55. *Poria carbonica* Overh. Annual, tough-corky, pore surface white to ivory, the pores 3–5 per mm.; tube layer up to 10 mm. thick; context ivory, corky, with thin pale-brownish, cartilaginous layers or areas, the hyphae hyaline, of two types, some very thick-walled, rarely branched, sinuous, nonseptate, 5–9  $\mu$  in diameter, others thin-walled, often branched, occasionally septate, 2.5–4  $\mu$  in diameter; spores hyaline, smooth, cylindrical, 5–5.5 x 2–2.5  $\mu$ . Associated with a brown cubical rot of coniferous slash, in British Columbia, Montana, Washington, “Idaho, and Oregon”.

56. *Poria monticola* Murr. Annual, drying brittle; pore surface white or drying tan, the pores 2–4 per mm.; tube layer up to 3 mm. thick; context whitish, soft to corky, less than 0.5 mm. thick, the hyphae hyaline, of two types, some thick-walled, occasionally branched, rarely clamped, 2.5–6  $\mu$  in diameter; others thin-walled, rarely branched, rarely clamped, 2–4  $\mu$  in diameter; spores hyaline, smooth, short-cylindrical, 4–5 x 2–2.5  $\mu$ . Associated with a brown cubical rot of coniferous slash and structural timbers, in British Columbia, Montana, Idaho, “Washington, and Oregon”.

57. *Poria lenis* (Karst.) Sacc. Annual, soft, light in weight; margin often cottony; pore surface ivory to pale tan, the pores 4–7 per mm.; context thin, soft-fibrous, the hyphae hyaline, thick-walled, rarely branched, nonseptate or very rarely clamped, 2–3  $\mu$  in diameter; spores hyaline, smooth, lunate or varying to allantoid, 3.5–4 x 1.5–2  $\mu$ . Associated with a white rot of coniferous and hardwood slash, in British Columbia, Montana, Idaho, Oregon, “Washington, and Wyoming”.

58. *Poria oleagina* Overh. Perennial, cheesy-tough, drying rigid and slightly resinous; taste bitter; pore surface ivory to buff, the pores

5-6 per mm.; context ivory, tough-corky, the hyphae hyaline, thick- to thin-walled, often branched, nonseptate, with frequent knobby swellings, mostly 2-3, but occasionally up to  $6\ \mu$  in diameter; fusoid cystidioles abundant,  $10-12 \times 4-5\ \mu$ ; spores hyaline, smooth, cylindrical, often slightly curved,  $3.5-5 \times 1.5-2\ \mu$ . Associated with a brown cubical rot of coniferous slash, in Montana and "British Columbia".

59. *Poria stenospora* Overh. Annual, tough-corky; taste slowly bitter; pore surface cream to pale tan, the pores circular, 6-7 per mm.; context ivory, corky, the hyphae hyaline, thick-walled, very rarely clamped, some rarely branched,  $3-5\ \mu$  in diameter, others much-branched,  $1.5-2.5\ \mu$  in diameter; spores hyaline, smooth, cylindrical, often attenuated at one end,  $8-10 \times 1.5-2\ \mu$ . On coniferous slash, in British Columbia and Washington.

60. *Poria albobrunnea* (Rom.) Baxter. Annual or rarely reviving a second year, soft and cottony to corky; pore surface white to cream, often drying light reddish-brown, the pores 5-7 per mm.; context whitish to pale tan, with a thin layer of dark brown tissue next to the substratum, the hyphae of the upper part hyaline, frequently branched, thin- to thick-walled, rarely clamped,  $2-4\ \mu$  in diameter, those of the lower brown layer pale to dark brown, otherwise similar; hymenial layer yellowish at the base of the tubes; spores hyaline, smooth, cylindrical, mostly curved,  $4-5.5 \times 1-1.5\ \mu$ . Associated with a brown cubical rot of coniferous slash, in Montana, Idaho, Colorado, "British Columbia, Alberta, and Oregon".

61. *Poria alutacea* Lowe. Annual, soft; pore surface white to ivory, the pores 5-7 per mm.; margin conspicuously rhizomorphic; context white, the hyphae hyaline, thick- to thin-walled, nonseptate,  $1.5-2.5\ \mu$  in diameter; spores hyaline, smooth, short-cylindrical, slightly curved,  $3-3.5 \times 1-1.5\ \mu$ . On alder slash, in Montana, Idaho, and Washington.

62. *Poria cinerascens* (Bres.) Sacc. Annual or reviving a second year, tough, coriaceous; pore surface ivory to cinereous, the pores 5-6 per mm.; context ivory, corky, the hyphae hyaline, some extremely thick-walled, rarely branched, nonseptate,  $3-8\ \mu$  in diameter, others thin-walled, often branched, clamped,  $2.5-3.5\ \mu$  in diameter; spores hyaline, smooth, cylindrical, curved,  $5-7 \times 1.5-2\ \mu$ . Associated with a brown rot of hardwood and coniferous slash, in British Columbia, Montana, Idaho, Washington, and Colorado.

63. *Poria subincarnata* (Peck) Murr. Annual, tough-corky, pore surface cream or drying pale buff, often extensively cracked, the pores circular to angular, 6-8 per mm.; context cream or pale buff, corky, the hyphae hyaline, thick-walled, rarely branched, nonseptate,  $2.5-5\ \mu$  in diameter; hyphal pegs usually present; spores hyaline, smooth, cylindrical, curved,  $4-5 \times 1-1.5\ \mu$ . Associated with a brown rot of coniferous slash, in Montana, Idaho, Wyoming, "British Columbia, and Oregon".

64. *Poria sitchensis* Baxter. Perennial, tough; taste mildly resinous; pore surface ivory to flesh colored, often with circular, pale



brownish depressions up to 2 mm. in diameter, the pores 6–8 per mm.; margin becoming resinous, reddish-brown; context whitish, corky, the hyphae hyaline, thick-walled, nonseptate, some rarely branched, 2.5–5  $\mu$  in diameter, others much branched, 2–2.5  $\mu$  in diameter; spores hyaline, smooth, cylindrical, curved, 4–5 x 1–1.5  $\mu$ . Associated with a brown cubical rot of coniferous slash, in Montana, Idaho, “British Columbia, and Oregon”.

#### OMITTED SPECIES

*Poria attenuata* (Peck) Cooke. Reported from Mont. and Idaho by Cooke and Shaw (1948). A synonym of *Poria eupora*.

*Poria aurantiaca* (Rostk.) Sacc. Reported from Mont., Idaho, and Wash. by Cooke and Shaw (1948). The specimen cited from Priest River, Idaho, should be referred to *Poria rubens*. No other specimens have been seen. Lowe (1947) has pointed out that *P. rubens* is the same as *Poria aurantiaca* var. *saloisensis* (Karst.) Sacc. The later name is used here since a new recombination has not been made.

*Poria aurea* Peck. Reported from B. C. by Cooke and Shaw (1948). The type material of this species is very similar to *Poria subacida*, differing only in its larger cystidia.

*Poria blytii* (Fries) Sacc. Reported from Mont. by Cooke and Shaw (1948). The specimen cited should be referred to *Poria luteoalba*. Murrill (1921) places *P. blytii* in synonymy with *P. eupora*.

*Poria bresadolae* Bourd. & Galz. Reported from Ore. by Cooke (1942). The specimen cited should be referred to *P. luteoalba*. Baxter (1939) lists *P. bresadolae* as a synonym of *P. purpurea*.

*Poria callosa* (Fries) Cooke. Reported from B. C., Mont., Idaho, Wash., and Ore. by Cooke and Shaw (1948). This name has been applied to resupinate specimens of *Trametes serialis* Fries.

*Poria carbonaria* (Berk. & Curt.) Reported from Mont. by Weir (1917). Resupinate *Trametes carbonaria* (Berk. & Curt.) Overh.

*Poria chromatica* Overh. Reported from B. C., Mont., Idaho, and Colo. by Overholts (1939). A probable synonym of *Poria crustulina*.

*Poria colorea* Overh. & Englerth. Reported from B. C., Wash., and Ore. by Cooke and Shaw (1948). This name has been applied to a yellow form of *P. subacida*.

*Poria confusa* Bres. Reported from Wash. by Cooke and Shaw (1948). The specimen reported on quaking aspen should be referred to *P. similis*. The other has not been seen.

*Poria coniferarum* Baxter. Reported from Alta. and Idaho by Baxter (1938). The type material of this species has not been seen, but the descriptive material suggests that it is a color form of *P. bombycina*. The specimen cited from Idaho by Cooke and Shaw (1948) should be referred to the latter species.

*Poria contigua* (Pers.) Karst. Reported from Mont., Wash., and

Ore. by Cooke and Shaw (1948). The identity of this fungus is not well understood. No specimens have been seen.

*Poria cylindrispora* Lloyd. Reported from Mont. and Ore. by Cooke and Shaw (1948). Lowe (1948) considers this to be a thick form of *P. ferrea*.

*Poria decolorans* (Schw.) Cooke. Reported from B. C., Idaho, and Wash. by Cooke and Shaw (1948). This name has been used for the plant here referred to *Poria sanguinolenta*.

*Poria dichroa* Bres. Reported from Idaho and Mont. by Bresadola (1925). A synonym of *Poria albobrunnea*.

*Poria emollita* (Fries) Karst. Reported from Wash. and Ore. by Cooke and Shaw (1948). The specimen cited from the Peavy Arboretum, Ore., should be referred to *P. ferrea*. The others have not been seen.

*Poria expallescent* Karst. Reported from Idaho by Cooke and Shaw (1948). The specimen cited from Bovill should be referred to *P. albipellucida*, and the one from Coolin to *P. undata*. The others have not been seen.

*Poria flavicans* (Karst.) Sacc. Reported from B. C., Mont., and Idaho by Baxter (1936), and Ore. by Cooke (1942). The Ore. specimen is now sterile and unidentifiable. The others have not been seen.

*Poria fulvella* Bres. Reported from Idaho by Bresadola (1925). A synonym of *Poria bombycina*.

*Poria fulvescens* Bres. Reported from Idaho and Wash. by Cooke and Shaw (1948). The specimens cited from Coolin and from Kooskia, Idaho, should be referred to *P. aneirina*. The other one has not been seen.

*Poria fulvida* Ellis. Reported from Mont. by Weir (1917). This is a probable synonym of *P. ferrea*.

*Poria fuscomarginata* (Berk.) Cooke. Reported from Idaho by Cooke and Shaw (1948). The specimen cited should be referred to *P. subacida*.

*Poria hibernica* (Berk. & Br.) Sacc. Reported from Mont., Idaho, and Wash. by Cooke and Shaw (1948). The specimens cited from Coolin, Idaho, and Anaconda, Mont., should be referred to *P. subincarnata*. The others have not been seen.

*Poria homaema* Berk. Reported from Mont. by Weir (1917). This is probably a misspelling of *P. omaema*, which is reported by Lowe (1949) to be a synonym of *P. subacida*.

*Poria humilis* Murr. Reported from Ore. by Cooke and Shaw (1948). The specimens cited have not been seen.

*Poria incerta* (Pers.) Murr. Reported from Idaho, Wash., and Ore. by Cooke and Shaw (1948). The specimens cited have not been seen. This name has been applied frequently to specimens of *P. versipora*.

*Poria incrustans* (Berk. & Curt.) Cooke. Reported from Ore. by Zeller (1929). No specimens have been seen.



*Poria inermis* Ell. & Everh. Reported from Wash. by Cooke and Shaw (1948). The specimen cited has not been seen.

*Poria laminata* Murr. Reported from Mont. by Weir (1917). This name has been applied to the resupinate form of *Fomes robustus* Karst.

*Poria marginella* (Peck) Sacc. Reported from Mont., Idaho, and Wash. by Cooke and Shaw (1948). A synonym of *P. ferrugineofusca*.

*Poria medulla-panis* (Pers.) Fries. Reported from Mont. by Weir (1917). This is a probable synonym of *P. unita*.

*Poria mucida* Pers. Reported from Ore. by Zeller (1929). The specimens have not been seen. This name has frequently been applied to specimens of *P. versipora*.

*Poria obducens* (Pers.) Quél. Reported from Wash. and Ore. by Cooke and Shaw (1948), from Mont. by Weir (1917), and from Colo. by Kauffman (1921). This name has been applied to resupinate specimens of *Fomes connatus* (Weinm.) Gill. The specimens cited have not been seen.

*Poria odora* (Peck) Sacc. Reported from Idaho by Cooke and Shaw (1948). The specimens cited have not been seen. This species differs from *P. rixosa* in lacking cystidia.

*Poria pereffusa* Murr. Reported from Mont. by Weir (1917). This is a probable synonym of *P. laevigata*.

*Poria pulchella* (Schw.) Cooke. Reported from B. C., Mont., Idaho, and Wash. by Cooke and Shaw (1948). Lowe (1946) considers this to be a variety of *P. tenuis*. The specimens cited have not been seen.

*Poria radula* (Pers.) Cooke. Reported from Wash. by Cooke and Shaw (1948). The specimen cited has not been seen.

*Poria resinascens* (Rom.) Lund. & Nannf. Reported from Wyo. by Baxter (1943). The type specimens have been studied, but the identity of this species remains uncertain.

*Poria rhodella* (Fries) Sacc. Reported from Wash. by Cooke and Shaw (1948). The specimen cited should be referred to *P. spissa*.

*Poria rufa* (Schröd. ex Fries) Cooke. Reported from Mont., Idaho, Wash., and Ore. by Cooke and Shaw (1948). Same as the plant here referred to *Poria taxicola*.

*Poria salmonicolor* (Berk. & Curt.) Cooke. Reported from Colo. by Kauffman (1923). The specimen cited is sterile and unidentifiable.

*Poria sericeomollis* (Rom.) Baxter. Reported from B. C., Idaho, and Wash. by Cooke and Shaw (1948). The specimens cited have not been seen.

*Poria stellae* Pilát. Reported by Pilát (1936-42) from Wyo. and Idaho. The Wyo. specimen, from Fox Park, is probably the same as one at Beltsville under the name of *Poria hibernica*, and which should be referred to *Poria subincarnata*. The Idaho specimen has not been seen.

*Poria subavellanea* Murr. Reported from Idaho, Wash., and Ore. by Cooke and Shaw (1948). According to Lowe (1947) the type material of this species does not differ from *Poria cinerascens*.

*Poria subfusco-flavida* Rostk. Reported from Idaho and Wash. by Cooke and Shaw (1948). The specimens cited have not been seen. Pilát (1936-42) lists this as a synonym of *Poria crassa*. The name has also frequently been applied to specimens of *P. cinerascens*.

*Poria subrufa* Ell. & Dearn. Reported from Idaho by Cooke and Shaw (1948). The specimen cited has not been seen.

*Poria subspadicea* Fries. Reported from Mont. by Weir (1917). No specimens have been seen.

*Poria subsulphurea* (Ell. & Ev.) Murr. Reported from Colo. by Murrill (1919). No specimens have been seen.

*Poria subtilis* Bres. Reported from Idaho by Cooke and Shaw (1948). This is listed by Lowe (1946) as a synonym of *Poria candidissima*. The specimen cited should be referred to that species.

*Poria tacamahacae* Baxter. Reported from Alta. and Idaho by Baxter (1939). The type material of this species has not been seen, but it is apparently very similar to *Poria pannocincta*.

*Poria vicina* Bres. Reported from Idaho and Wash. by Bresadola (1925). A synonym of *Poria corticola*.

*Poria vincta* (Berk.) Sacc. Reported from Idaho by Cooke and Shaw (1948). The specimen cited has not been seen. This is a tropical species and frequently the name has been erroneously applied to *Poria eupora*.

*Poria violacea* Fries. Reported from Mont. by Weir (1917). No specimens have been seen.

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## Studies on the Development of the Embryo and Seed of *Hevea brasiliensis* in Culture

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The normal development of the embryo and seedling of the Para rubber tree, *Hevea brasiliensis* (Wild. ex. Adr. Juss.) Muell. Arg.), has been described previously (Muzik, 1954). Studies on the growth of the seed and the embryo in agar culture are described in the present paper. Immature embryos of a number of species of plants have been successfully grown to maturity on various agar nutrient media by La Rue (1936) and others. This procedure has been emphasized as a means of growing immature embryos which do not develop in the seed due to incompatibility between embryos and endosperm (Tukey, 1933). The use of coconut milk has been found especially advantageous for very young embryos (van Overbeck, et. al., 1942). Such a procedure might possibly have application in *Hevea brasiliensis* since only 5 to 10 per cent of hand-pollinated flowers usually mature fruit. The remainder of the fruits fall during the first 6 to 8 weeks of the maturation period of approximately 14 weeks.

### MATERIALS AND METHODS

Nutrient media of La Rue (1936) and White (1943), with and without additions of sugar, coconut milk or indole-3-acetic acid were used for the cultures. When used, the coconut milk was taken from ripe coconuts under sterile conditions and substituted for one-third of the water in the medium and the indole-3-acetic acid was added at the rate of 1:5,000,000. Sugar was added at the rate of 20 grams per liter.

The fruits and seeds were sterilized with a solution of sodium hypochlorite (20 per cent Clorox) for twenty minutes, or by dipping the fruit in alcohol, flaming it and dissecting out the ovules and embryos with sterile tools. Erlenmeyer flasks, or bottles with cotton plugs or screw caps were used. Both whole embryos and pieces of embryos were cultured.

### GROWTH OF WHOLE EMBRYOS

The embryo passes through four distinct stages of development 1) ovoid, 2) heart-shaped, 3) spatulate, in which the cotyledons elongate, and 4) the mature or very broadly spatulate shape. In the ovoid and heart-shaped stages, it lies within a liquid to gelatinous endosperm. The endosperm is later absorbed and replaced by the nucellus (perisperm) which forms the bulk of the tissue of the mature seed.



Embryo cultures were made throughout the developmental period, beginning with the ovoid stage. The embryo is cream-colored or white at all stages of growth when removed from the seed. Attempts at culturing embryos of any early stage with or without sugar, indole-3-acetic acid, or coconut milk were unsuccessful. When the embryo was placed in culture before it reached full-size, *i.e.*, 10-12 weeks after fertilization, it failed to grow. Several of the embryos in the early spatulate stage turned green and the cotyledons opened up and lay flat on the agar. The embryos, however, did not develop further although they lived for many weeks.

Mature embryos began growth almost immediately in culture and turned green within two days. Development resembled that of the embryo in the seed, except that the cotyledons separated and lay flat on the agar, as they cannot do normally in the seed. The embryo grew equally well on all the media used and showed no apparent reaction to the presence or absence of sugar, indole-3-acetic acid or coconut milk.

In normal growth, the plumule is humped as it grows out of the seed (Muzik, 1954). Although there was no pressure of any kind on the young plumule in culture, since the cotyledons opened up and lay flat, it still grew in the typical humped shape. In only one of several hundred cultures did the plumule grow without humping. This was a culture of half a seed, which had been cut transversely, removing half the perisperm and half of the cotyledons, but leaving the embryo axis intact. In this instance, the plumule grew out between the cotyledons while the hypocotyl and radicle grew in the normal way, producing an apparently normal plant. In an attempt to duplicate this unusual reversal of polarity, seeds cut in a similar way were cultured on agar or planted in soil, but all grew normally, *i.e.*, with the hump.

#### GROWTH OF EMBRYO PIECES

Several embryo axes from mature embryos with the cotyledons removed were placed in culture. Although they turned green and lived for several weeks and often increased about five times in volume, they did not develop leaves or roots. La Rue (1933) has reported that seedlings of a number of other species of plants failed to grow in a moist chamber when the cotyledons were excised, despite the fact that the plumule was already partially developed.

The axes of several embryos were separated from the cotyledons and cut longitudinally and transversely into halves, thirds, fourths and fifths. Although these pieces often lived for several weeks and a few lived as long as seven months they never developed into complete plants. An adventitious root was sometimes produced but the primary root never developed.

If the embryo axes were attached to a piece of cotyledon, they sometimes grew. It was found that a relationship between the amount of cotyledons present and the growth of the plant existed. The axis plus less than a third of the cotyledons grew very slowly and did not always develop into a healthy plant. The axis and one-third of the

cotyledons grew slowly but usually developed into a healthy plant. The axis with two-thirds of the cotyledons developed almost as rapidly as the complete embryo.

#### DEVELOPMENT OF OVULES

Cultures of many stages of immature and mature ovules were made. The immature ovules failed to develop in any of the media used.

The integuments were always removed for the culture of the mature ovule. The embryos promptly began to grow. Growth was similar to that in planted seeds, except that it began a day or two sooner on the agar. The seeds on the agar were sometimes split apart by the swelling of the cotyledons.

The perisperm in the cultured seeds remained firm and was not absorbed even when the plants were in culture for 3-6 months, although in the seeds planted in soil, it disappeared in three to four weeks, except for a thin periphery. Sometimes the perisperm in the ovules in culture turned green where separation from the cotyledons exposed them to light but no further development occurred. Pieces of perisperm placed in culture turned green and increased in volume but did not regenerate roots or buds although remaining apparently firm and healthy for 6-8 months.

#### REGENERATION OF ROOTS ON COTYLEDONS

Formation of roots on mature cotyledons of a number of plants has been reported by La Rue (1933). Rooting of *Hevea* cotyledons may occur in nature if the seedling is broken off from the cotyledons (Bobiloeff, 1919 and Sprecher, 1915).

Immature cotyledons did not grow in culture. In the early spatulate stage, they sometimes turned a pale green but did not develop further.

Mature or nearly mature cotyledons, 10-14 weeks after fertilization formed roots very readily on nutrient media or in a damp chamber. They were cut off with care so as not to include any axillary buds or any part of the hypocotyl. The cotyledon changed from creamy white to green within two or three days after culturing. Roots generally appeared at the cut end nearest the petiole within five to eight days although it sometimes took much longer. Some were in culture eight months without forming roots. Both whole cotyledons and pieces have been rooted but rooting was most rapid when a piece of perisperm was attached. It is of interest that the perisperm was not absorbed but remained firm. There was usually no callus formation. Pieces as small as two millimeters in diameter have formed roots.

The cut end of the cotyledon lamina rooted almost as readily as the bases of the petioles. A rooted half of a cotyledon is shown in Fig. 1. Occasionally the entire cut surface of the petiole developed one massive root, about five millimeters in diameter. These roots showed no consistent geotropic response. They usually grew in the direction in which they began, whether up or down.



Roots appeared on the unwounded petiole within ten days and on the unwounded sides of the lamina only after six months. The roots were always associated with a vascular bundle. The origin of a root is shown in Figure 2.

The roots grew very rapidly, as much as 1.5 centimeters per day, and sometimes curled several times around the container. In the growth of the roots, the cotyledon was sometimes lifted completely off the surface of the agar, or the agar was cracked into segments. Single cotyledons in culture often underwent violent twisting and turning. This same twisting also occurred in a damp chamber on moist toweling but not to the same extent.



FIG. 1. Rooted half of a cotyledon. Roots oriented as shown, thus exhibiting an apparently negative geotropism. FIG. 2. Early stage of root formation on a cotyledon. These roots always originate near a vascular bundle. FIG. 3. Rooted cotyledons which have split the seed coat, due to the increase in size of the lamina. FIG. 4. Shoot regenerated from a cotyledon. It first became visible forty-three days after the cotyledon was placed on the agar medium. When photographed, the shoot was five centimeters high.

In the normal process of seed germinations, the petioles of the cotyledons elongated to a length of slightly more than a centimeter. If the seedling were detached from the cotyledons when it was three to six inches high, the latter still rooted. The cotyledons swelled and sometimes split the hard seed coat as shown in Figure 3. If the young plant were left attached to one cotyledon the other developed an extensive root system. No cotyledon ever regenerated roots while attached to the embryo axis.

The addition of sugar, coconut milk or indole-3-acetic acid to the agar medium did not affect the rate of regeneration or the number of roots formed on the excised cotyledons.

#### FORMATION OF BUDS ON COTYLEDONS

Formation of a bud was witnessed on only two cotyledons, one from a seed of Tjirandji 1 and one from a seed of Waringiana 4. One of these was cultured on La Rue's medium plus 1:5,000,000 indole-3-acetic acid. The culture consisted of one cotyledon and half of a perisperm. The cotyledon rooted very freely at the base of the petiole. The stem was first seen eight days later and grew to be about two centimeters long before becoming infected. The other cotyledon was cultured in La Rue's medium without added hormone. The culture consisted of one cotyledon and half of a perisperm. Roots were formed in ten days, but a bud did not appear until forty-three days after culturing. It grew to a length of five centimeters before becoming infected and is shown in Figure 4.

#### LENTICEL DEVELOPMENT IN EMBRYOS IN CULTURE FOR LONG PERIODS

Bobilioff (1923) has reported the abnormal development of lenticels of rubber seedling stems under water. Similar growths occurred on young plants in agar culture, although the stems were not immersed. The first appeared as white semi-oval masses on the stem or cotyledon petiole, later turned dark brown and coalesced into ridges and finally covered the stem. This growth was an extension of the complementary tissue of the lenticel. When transplanted into soil, these plants grew very well. The lenticular growth dried up and sloughed off within a few weeks. Cork formation occurred as soon as this growth was removed.

#### DISCUSSION

Embryos of *Hevea brasiliensis* failed to grow in culture unless they were nearly mature despite the addition of coconut milk or indole-3-acetic acid to the medium. Therefore, this method does not appear to be useful in growing hybrid embryos of this species. Embryos failed to grow unless attached to approximately one-third of the cotyledons, suggesting that the ability of the embryo axes to synthesize foods may be limited. It is curious that the perisperm was not absorbed by the embryo or cotyledon in culture. It disappeared within a few days in seeds planted in soil indicating that fungi and bacteria may normally



play an important role in its disappearance. Buds were formed less frequently on the cotyledons than were roots. According to Swingle (1940) formation of buds by cotyledons is relatively rare, although La Rue (1933) has reported regeneration of roots and buds in a number of plants, both woody and herbaceous. However, an examination of his paper revealed that the genera whose cotyledons regenerated buds have a seed which contains no endosperm or at the most a slight amount. Thus in plants, like *Hevea*, with a copious perisperm and relatively thin cotyledons, the seed may contain a substance helpful for bud and root formation. Both of the cotyledons which regenerated buds were in contact with half a perisperm, and those in contact with perisperm tissue rooted most rapidly.

The abnormal growth of the lenticels may have occurred on embryos in culture because of the high humidity and sterility of the agar medium. Bobilioff (1923) attributed a similar growth under water to a need for more oxygen. Since the stems of plants grown in culture for several weeks are covered with a layer which may be two millimeters thick, the amount of oxygen absorbed is probably decreased rather than increased.

#### SUMMARY

Embryos of *Hevea brasiliensis* were placed in nutrient agar culture in all stages of development. Only the mature or nearly mature embryos continued to develop. These embryos usually followed the normal pattern of germination and early growth. Unless one-third or more of the cotyledons was attached to the embryo axis, it failed to grow. Immature ovules did not develop in culture. In mature ovules, the perisperm turned green but did not regenerate roots or buds. Mature cotyledons rooted readily when separated from the embryo in two cases also regenerated a new shoot. Abnormal growth of the complementary tissue of the lenticel occurred on young plants in culture.

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## Nomenclatorial Notes in *Bulbophyllum*

ALEX D. HAWKES  
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During the preparation of a definitive check-list of the orchidaceous genus *Bulbophyllum* Thou., several alterations in names, because of their being homonyms of earlier epithets, have proven necessary. These are indicated below.

### ***Bulbophyllum africanum*, nom. nov.**

(*Bulbophyllum albidum* DeWild. in Rev. Zool. Afr. **9**, Suppl. Bot. **29**. 1921, not (Wight) Hk.f., 1890.)

DeWildemann's *B. albidum* was described from the Belgian Congo. *B. albidum* (Wight) Hk.f. is a member of the section *Cirrhopetalum*, designated as a native of Perak, in the Malay Peninsula, though it is not mentioned in Holttum's recent *Orchids of Malaya* (*Flora of Malaya*, Vol. 1. 1953.).

### ***Bulbophyllum Andreeae*, nom. nov.**

(*Bulbophyllum acuminatum* Schltr. in Fedde, Repert. Spec. Nov., Beih. **1**: 727. 1913, not (Ridl.) Ridl., 1907.)

Schlechter's *B. acuminatum* is a member of the section *Dialeipanthè* from Dutch New Guinea. *B. acuminatum* (Ridl.) Ridl. is based on *Cirrhopetalum acuminatum* Ridl., a native of the Malay Peninsula. The new name is given in honor of Andrée (Mrs. John M.) Millar, of Bulolo, Territory of New Guinea, in recognition of her work in the orchids of her adopted land.

### ***Bulbophyllum Frappieri*, nom. nov.**

(*Bulbophyllum compressum* Frapp. ex Cordem., Fl. Île Réunion **172**. 1895, not Teijsm. & Binn., 1862.)

Frappier's *B. compressum* is obviously a completely distinct species from the earlier one of Teijsmann and Binnendijk; the latter is a native of Sumatra, while that of Frappier inhabits the Mascarene Islands. The new name is given in memory of the original describer of the Mascarene species.

### ***Bulbophyllum Holttumii*, nom. nov.**

(*Bulbophyllum apiferum* Carr in Gard. Bull. Straits Settlement. **5**: 133. 1930, not Batem. ex Steud., 1846.)

Carr's *B. apiferum* is an attractive species with pink, purple-veined and -spotted flowers, native in the Malay Peninsula. The name of Bateman was applied to a completely different plant in Tropical Africa. The new epithet is given to honor Dr. R. Eric Holttum, an avid student of the Orchidaceae of Malaya, and author of *The Orchids of Malaya*.

**Bulbophyllum Katherinae**, nom. nov.

(*Bulbophyllum carinatum* Cgn. in Jour. des Orch. **6**: 216. 1895; and in Lindenia **11**: 20, 33, pl. 495. 1895, not (Teijsm. & Binn.) Naves, 1880.)

*Bulbophyllum carinatum* (Teijsm. & Binn.) Naves was based on *Cirrhopetalum carinatum* Teijsm. & Binn., and is a confused name. The later use by Cogniaux of the same epithet for a handsome Bornean orchid makes a new name necessary. The present name is given in honor of the author's mother, Mrs. Katherine H. Chatham, who has through the years been a never failing source of inspiration and encouragement.

**Bulbophyllum Moirianum**, nom. nov.

(*Bulbophyllum ciliatum* Schltr. in Engl., Bot. Jahrb. **38**: 156. 1906, not (Bl.) Ldl., 1830.)

Schlechter's *B. ciliatum* is an African plant, completely distinct from the Malayan *B. ciliatum* (Bl.) Ldl., based on *Diphyes ciliata* Bl. The new epithet is given in honor of Mr. and Mrs. W. W. G. Moir of Honolulu, who have assisted the author on many occasions in the field of taxonomy of horticulturally important orchids.

**Bulbophyllum Sladeanum**, nom. nov.

(*Bulbophyllum cochleatum* Schltr. in Fedde, Repert. Spec. Nov. **8**: 455. 1910, not Ldl., 1862.)

Schlechter's *B. cochleatum* is an interesting species from Australia, while the earlier one of Lindley is Tropical African and a completely different entity. The new epithet is given in honor of Mr. G. Hermon Slade, Homebush, N.S.W., Australia, long an avid student of his country's orchids.

**Bulbophyllum Summerhayesii**, nom. nov.

(*Bulbophyllum Clarkei* Schltr. in Engl., Bot. Jahrb. **38**: 13. 1906, not Rchb.f., 1888.)

The *B. Clarkei* of Schlechter is an unusual Tropical African species, totally distinct from the prior *B. Clarkei* of Reichenbach *filius*, found in the Himalayas. The new epithet is given in honor of Dr. Victor S. Summerhayes, Royal Botanic Gardens, Kew, England, a recognized authority on the Orchidaceae of Africa.

**Bulbophyllum Williamsii**, nom. nov.

(*Bulbophyllum caudatum* L. O. Wms. in Bot. Mus. Leaf. Harv. Univ. **6**: 99. 1938, not Ldl. in Wall., 1832.)

Williams' *B. caudatum* is a member of the section *Monanthaparra* from Mindanao in the Philippines. Lindley's *B. caudatum* is a completely distinct Himalayan plant. The new epithet is given in recognition of Dr. Louis O. Williams, who established the name for the Philippine species and is a noted scholar of the orchids of those islands.



## Katherinea, a New Name for the Orchid Genus *Sarcopodium*

ALEX D. HAWKES  
(Pasadena, California)

In a recent issue of the *Kew Bulletin*, we noted with considerable interest the usage of a generic name for a group of fungi which is duplicated by one in the Orchidaceae, namely *Sarcopodium*. Upon inquiry to Dr. Donald P. Rogers of The New York Botanical Garden, we were informed that the orchid group, *Sarcopodium* Ldl. & Paxt. is predated by *Sarcopodium* Ehrenb., hence a new name must be found for the orchidaceous genus.

### **Katherinea** nom. nov.

*Sarcopodium* Ldl. & Paxt. in Paxt. Flow. Gard. **1**: 136. 1853 (not Ehrenb., Sylv. Myc. Berol. **23**. 1818 (pre-starting-point) ex Brongniart, Dict. Sci. Nat. **33**: 546. 1824; Fr., Syst. Orb. Veg. **190**. 1825; Fr., Summ. Veg. Scand. **471**. 1849.).

*Bulbophyllum* Thou. § *Sarcopodium* Rchb.f. in Walp. Ann. **6**: 243. 1861.

*Dendrobium* Sw. § *Sarcopodium* Bth. & Hk.f., Gen. Plant. **3**(2): 499. 1883.

The new name is bestowed in honor of Katherine H. Chatham, the writer's mother, who for more than fifteen years has assiduously aided and encouraged him in his studies of the orchid family.

The species which comprise *Katherinea* have often in the past been included in either *Bulbophyllum* Thou. or in *Dendrobium* Sw., but they appear adequately distinct to warrant recognition. We consider this group to represent a divergent offshoot from *Dendrobium* Sw., differing from that aggregation in the following characters: the pseudobulbous stems are composed of a single internodal joint; the racemes are terminal or pseudoterminal (a characteristic shared with a very few species of *Dendrobium*); and the rhizomes are very elongated and creeping, not abbreviated.

As now delimited, *Katherinea* consists of 28 species, these ranging from the Himalayas and the Philippine Islands throughout Southeast Asia and Indonesia to New Guinea. Several of these often spectacularly beautiful orchids are in cultivation.

The following transfers are necessary at this time:

### **Katherinea acuminata** (Rolfe) comb. nov.

*Dendrobium acuminatum* Rolfe in Ames, Orchid. **1**: 86. 1905.

*Sarcopodium acuminatum* Rolfe in Orch. Rev. **18**: 239. 1910.

PHILIPPINES: Luzon.

—var. **Lyoni** (Ames) comb. nov.

*Dendrobium Lyoni* Ames, Orchid. **2**: 177. 1908.

*Dendrobium acuminatum* Rolfe ex Lyon in Gard. Chron. (2): 210, fig. 88. 1907 (not Rolfe, 1905).

*Sarcopodium Lyoni* Rolfe in Orch. Rev. **18**: 240. 1910.

*Sarcopodium acuminatum* (Rolfe) Rolfe var. *Lyoni* Krzl. in Engl., Pflanzenr. **4**: 50, ii, B, 21: 329. 1910.

PHILIPPINES: Luzon.

**Katherinea ampla** (Ldl.) comb. nov.

*Dendrobium amplum* Ldl. in Wall., Catal. no. 2001. 1828.

*Sarcopodium amplum* Ldl. & Paxt. in Paxt. Flow. Gard. 1: 155. 1853.

*Bulbophyllum amplum* Rchb.f. in Walp. Ann. 6: 244. 1861.

INDIA: Assam; Khasia Hills. NEPAL.

This is the type of the genus, based on Lindley & Paxton's *Sarcopodium*.

**Katherinea Beccariana** (Krzl.) comb. nov.

*Sarcopodium Beccarianum* Krzl. in Engl., Pflanzenr. 4: 50, ii, B, 21: 322, fig. 30. 1910.

BORNEO: Sarawak.

**Katherinea citrino-castanea** (Burkill) comb. nov.

*Dendrobium citrino-castaneum* Burkill in Gard. Bull. Straits Settlement. 3: 12. 1923.

*Sarcopodium citrino-castaneum* Ridl., Fl. Malay Penins. 4: 29. 1924.

MALAY PENINSULA.

Holttum has reduced this species to synonymy under *Dendrobium zebrinum* J. J. Sm. It perhaps is not distinct.

**Katherinea Coelogyne** (Rchb.f.) comb. nov.

*Dendrobium Coelogyne* Rchb.f. in Gard. Chron. 136. 1871.

*Sarcopodium Coelogyne* Rolfe in Orch. Rev. 18: 238. 1910.

BURMA: Tenasserim; Moulmein.

**Katherinea cymbidioides** (Bl.) comb. nov.

*Desmotrichum cymbidioides* Bl., Bijdr. 332. 1825.

*Dendrobium cymbidioides* Ldl., Gen. & Sp. Orch. Pl. 77. 1830.

*Dendrobium triflorum* Ldl., Gen. & Sp. Orch. Pl. 77. 1830.

*Dendrobium marginatum* Teijsm. & Binn. in Tijdschr. Nederl. Ind. 5: 490. 1853.

*Sarcopodium cymbidioides* Rolfe in Orch. Rev. 18: 238. 1910.

*Sarcopodium triflorum* Rolfe in Orch. Rev. 18: 239. 1910.

JAVA. PHILIPPINES: Luzon.

**Katherinea elongata** (Bl.) comb. nov.

*Desmotrichum elongatum* Bl., Bijdr. 332. 1825.

*Dendrobium elongatum* Ldl., Gen. & Sp. Orch. Pl. 77. 1830.

*Sarcopodium elongatum* Rolfe in Orch. Rev. 18: 239. 1910.

JAVA.

**Katherinea fuscescens** (Griff.) comb. nov.

*Dendrobium fuscescens* Griff., Notul. 3: 308. 1851.

*Sarcopodium fuscescens* Ldl., Fol. Orch. Sarcopod. 2. 1853.

*Bulbophyllum fuscescens* Rchb. f. in Walp. Ann. 6: 244. 1861.

INDIA: Bengal; Sikkim; Khasia Hills.

**Katherinea geminata** (Bl.) comb. nov.*Desmotrichum geminatum* Bl., Bijdr. 332. 1825.*Dendrobium geminatum* Ldl., Gen. & Sp. Orch. Pl. 77. 1830.*Sarcopodium geminatum* Rolfe in Orch. Rev. 18: 238. 1910.

SUMATRA. MALAY PENINSULA.

**Katherinea interrupta** (J. J. Sm.) comb. nov.*Dendrobium interruptum* J. J. Sm. in Bull. Dép. Agric. Ind. Néerl. 45: 18. 1911.*Sarcopodium interruptum* Merr. in Jour. As. Soc. Straits, Spec. No., 167. 1921.

BORNEO.

**Katherinea kinabaluensis** (Ridl.) comb. nov.*Dendrobium kinabaluense* Ridl. ex Stapf in Trans. Linn. Soc., II, 4: 234. 1894.*Sarcopodium kinabaluense* Rolfe in Orch. Rev. 18: 239. 1910.

BORNEO: Mt. Kinabalu.

**Katherinea labuana** (Ldl.) comb. nov.*Dendrobium labuanum* Ldl. in Jour. Linn. Soc. 3: 6. 1859.*Sarcopodium labuanum* Rolfe in Orch. Rev. 18: 239. 1910.

BORNEO: Labuan.

**Katherinea laurifolia** (Krzl.) comb. nov.*Sarcopodium laurifolium* Krzl. in Engl., Pflanzenr. 4, 50, ii, B, 21: 328. 1910.*Dendrobium laurifolium* J. J. Sm. in Fedde, Repert. Spec. Nov. 32: 286. 1933.

SUMATRA: Mt. Singalan.

**Katherinea longipes** (Hk.f.) comb. nov.*Dendrobium longipes* Hk.f., Fl. Brit. India 5: 713. 1890.*Sarcopodium longipes* Rolfe in Orch. Rev. 18: 238. 1910.

MALAY PENINSULA: Perak.

**Katherinea macropoda** (Hk.f.) comb. nov.*Dendrobium macropodum* Hk.f., Fl. Brit. India 5: 713. 1890.*Sarcopodium macropodum* Rolfe in Orch. Rev. 18: 238. 1910.

SUMATRA: Western part. JAVA. MALAY PENINSULA: Perak.

**Katherinea parvula** (Rolfe) comb. nov.*Dendrobium parvulum* Rolfe in Kew Bull. 127. 1899.*Sarcopodium parvulum* Krzl. in Engl., Pflanzenr. 4, 50, ii, B, 21: 322. 1910.

CELEBES: Minahassa.



**Katherinea perakensis** (Hk.f.) comb. nov.

*Dendrobium perakense* Hk.f., Fl. Brit. India **5**: 712. 1890.

*Sarcopodium perakense* Krzl. in Engl., Pflanzenr. **4**, 50, ii, B, 21: 328. 1910.

MALAY PENINSULA: Perak.

Peculiarly enough, this species is not mentioned by Holttum in his invaluable *Orchids of Malaya*.

**Katherinea prasina** (Ldl.) comb. nov.

*Dendrobium prasinum* Ldl. in Jour. Linn. Soc. **3**: 11. 1859.

*Sarcopodium prasinum* Krzl. in Engl., Pflanzenr. **4**, 50, ii, B, 21: 322. 1910.

FIJI ISLANDS: Suva.

**Katherinea pulchella** (Ridl.) comb. nov.

*Sarcopodium pulchellum* Ridl. in Jour. Fed. Malay States Mus. **8**(4): 93. 1917.

*Sarcopodium brevisulbum* J. J. Sm. in Bull. Jard. Bot. Buitenz., III, **10**: 62. 1928.

SUMATRA.

**Katherinea rotundata** (Ldl.) comb. nov.

*Sarcopodium rotundatum* Ldl., Fol. Orch. Sarcopod. **2**. 1853.

*Bulbophyllum rotundatum* Rchb.f. in Walp. Ann. **6**: 244. 1861.

*Dendrobium rotundatum* Bth. ex Bth. & Hk.f., Gen. Plant. 3(2): 499. 1883.

INDIA: Sikkim; Naga Hills.

**Katherinea simplex** (J. J. Sm.) comb. nov.

*Dendrobium simplex* J. J. Sm. in Bull. Jard. Bot. Buitenz. II, **2**: 8. 1911.

NEW GUINEA: Goliath Mountains.

**Katherinea specula** (J. J. Sm.) comb. nov.

*Dendrobium speculum* J. J. Sm. in Bull. Dép. Agric. Ind. Néerl. **5**: 34. 1907.

*Sarcopodium speculum* Carr in Gard. Bull. Straits Settle. **8**: 109. 1935.

BORNEO.

**Katherinea stella-silvae** (Loher & Krzl.) comb. nov.

*Sarcopodium stella-silvae* Loher & Krzl. in Fedde, Repert. Spec. Nov. **7**: 40. 1909.

*Dendrobium stella-silvae* Ames, Orchid. **5**: 139. 1915.

PHILIPPINES: Luzon.

**Katherinea Treacheriana** (Rchb.f.) comb. nov.

*Dendrobium Treacherianum* Rchb.f. ex Hk.f. in Bot. Mag. pl. 6591. 1881.

*Sarcopodium Treacherianum* Rolfe in Orch. Rev. **18**: 239. 1910.

BORNEO.

**Katherinea uncipes** (J. J. Sm.) comb. nov.

*Dendrobium uncipes* J. J. Sm. in Bull. Jard. Bot. Buitenz. II, **3**: 72. 1912.

NEW GUINEA: Goliath Mountains.

**Katherinea verrucifera** (J. J. Sm.) comb. nov.

*Dendrobium verruciferum* J. J. Sm. in Bull. Dép. Agric. Ind. Néerl. **15**: 12. 1908  
(not Rchb.f.).

*Sarcopodium verruciferum* Rolfe in Orch. Rev. **18**: 239. 1910.

BORNEO.

**Katherinea Wichersii** (Schltr.) comb. nov.

*Dendrobium Wichersii* Schltr. in Fedde, Repert Spec. Nov. **8**: 506. 1910.

*Sarcopodium Wichersii* Carr in Jour. As. Soc. Malaya **11**: 87, in obs. 1933.

SUMATRA.

**Katherinea zebrina** (J. J. Sm.) comb. nov.

*Dendrobium zebrinum* J. J. Sm., Icon. Bogor. **2**: pl. 113C. 1903.

*Sarcopodium zebrinum* Krzl. in Engl., Pflanzenr. **4**, 50, ii, B, 21: 324. 1910.

BORNEO: Kelam.

## Studies on Spirostreptoid Millipeds.

### III. The Genera *Ptenogonostreptus*, *Trichogonostreptus*, and *Oreastreptus*

RICHARD L. HOFFMAN

(Blacksburg, Virginia)

In South America occur three genera of the Spirostreptidae in which the outer margin of the telopodite of the male gonopod is distinctly fimbriate. Although this is a rather unusual character, and one which might be taken to indicate phylogenetic proximity of the three groups, the other characters of the genitalia are so divergent that I suspect the telopodital fimbriae may have originated independently in the different genera.

Attems, in his last paper on the spirostreptoids (1950), continued to maintain that all species sharing a particular development of the gonopod must belong to the same genus, regardless of all other structural peculiarities of the forms involved. With this point of view I must take exception, believing that such extreme conservatism actually does more to obscure the true relationships of systematic units than does equally zealous division and analysis. I feel that the importance of overall appearance should not be minimized in comparing the gonopods of various forms. The general configuration can be expected to be quite similar in animals related within generic limits, and a discordant shape should at once sound the alarm for a closer inspection of actual structure. If reliance would be placed more upon true similarities than upon highly subjective, verbally-characterizable features of doubtful systematic value (such as "*Tarsalrest*"), the day of eventual systematic harmony in this difficult order might be closer at hand.

In this paper I desire to show that the nature of the telopodite need not always be taken as an all-important generic criterion, and the association of these three genera under one title must not be considered an implication of relationship at a tribal level. A satisfactory classification of the spirostreptoids is still a much-needed undertaking, and one which will require far more detailed morphological work than has been done so far. Of great importance, without doubt, will be a comparative study of the gonopods, particularly their sternites and coral apodemes. The generally overlooked posterior gonopods, despite their rudimentary condition, may provide valuable clues to relationships. These areas seem to be more fundamental than the configuration of the terminal portions, which appear to be much more plastic and readily mutable. Even the latter parts will be of greater utility in classification when structural homologies have been worked out for the different forms, a matter which should be facilitated by the extensive terminology recently devised by the late Karl Verhoeff.

While writing the descriptions of the two new species named herein, I observed that the antennae of one bear sensory areas on two of the



articles, those of the other have but a single article so modified. There is nothing on this subject in the literature at my disposal, and I am unable to say whether the distribution of antennal sensory areas is a character of specific or generic significance. Other workers may wish to ascertain the condition in material which comes to their attention.

Dr. E. A. Chapin kindly loaned the material of *Trichogonostreptus* from the U. S. National Museum, and curators H. S. Dybas and R. L. Wenzel of the Chicago Natural History Museum arranged the loan of the specimen herein described as *Oreastreptus sanborni*. To the kind cooperation of these gentlemen this paper therefore owes its existence.

#### Genus TRICHOGONOSTREPTUS Carl

*Trichogonostreptus* Carl, 1918, Rev. Suisse Zool. **26**: 427. Attems, 1950, Ann. Naturh. Mus. Wien **57**: 202 (in part).

*Type*.—*T. ternetzi* Carl, by monotypy.

*Diagnosis*.—Tibiotarsus of gonopod with a series of 10 to 12 filamentous processes along the outer margin; distal end of paragonocoel broadly rounded, clothed with long setae, and usually exceeding end of telocoxite; latter diversified distally, with two lateral processes, the larger of which bears a small upright terminal projection; femoral process of telopodite moderately long and blade-like, projecting from femur just beyond the point of its exertion from the gonocoel. Legs with two ventral membraneous pads. Pores beginning on the 5th segment.

*Distribution*.—Paraguay, southern Brasil, Bolivia.

*Remarks*.—In his 1950 paper, Attems listed *Ptenogonostreptus* as a junior synonym of *Trichogonostreptus* (despite a difference in the origin of the pore series, a character which he used to distinguish other genera at three couplets in his key to genera), although his key accounted only for *T. ternetzi* Carl and *T. carli* Attems, and made no allowance for Schubart's *Ptenogonostreptus unilineatus*, the type species of its genus. Furthermore, since *carli* actually belongs in the new genus herein proposed as *Oreastreptus*, it becomes apparent that Attems included members of three distinct genera in his concept of *Trichogonostreptus*.

*Trichogonostreptus* was erected for the species *ternetzi*, and its author observed that "The principal character of this genus is found in the presence of piliform appendages on the margin of the posterior gonopod. None of the published descriptions of spirostreptoids mention such appendages, but, to judge from the very simplified and diagrammatic drawings, they seem to occur also in *Plusioporus camerani* Silvestri."

The illustrations in Silvestri's 1895 paper are unquestionably primitive, and it is not suprising that most of the species they represent have remained *inquirenda*. It must be remembered that in his early work, Silvestri did not place a great deal of reliance upon gonopod

structure for specific characters. *Plusioporus camerani* was described from the Apa River in Paraguay, and several years later (1902) was recorded by its author from Caiza, Bolivia, at a considerable elevation in the southern Andes. For a diplopod species to have such an extensive vertical range may seem unusual today but it apparently did not to Silvestri, for he not only identified the Caiza specimens as *camerani*, he also labeled them as *paratypes*! Under this mistaken identity, several specimens were sent to Dr. O. F. Cook, in a paratype exchange, and these form the type series of a new species of *Trichogonostreptus* to be described below.

The characters of the gonopods in this genus are best seen in a caudal view of the appendages. The configuration of the end of the telocoxite, in addition to being of generic importance, also provides good specific characters in the shape and arrangement of the terminal apophyses. The termination of the telocoxite proper (labeled B in the drawings) is bent distolaterad at an angle of about 45 degrees to the basal two-thirds of the structure, and is drawn out at the end a small curved process (C). Near the base of B at the mesial side is an upright process (A) of variable size and shape, but present in all three known forms. Laterally the basal margin of process B is reflected inward slightly and then laterad again, where it is produced into a long slender distolaterally directed process (D).

The telopodite itself is strongly twisted and jointed just beyond the point of its exsertion from the gonocoel, the moderate sized femoral process (FP) projecting just proximad of the joint. About midway along its length, the telopodite describes a complete circle or more, and the slender trichomes appear along the outer margin. Near the end, the telopodite is slightly expanded, and the seminal groove is carried out beyond this broadened area on a small slender solenomerite. Just distad of the telopodital joint is a blunt subtriangular spur on the outer margin.

The distal part of the paragonocoel somewhat exceeds the tip of the telocoxite except in *camerani*, and is set with numerous long slender macrosetae which are in strong contrast to the short stout bristles of the same area in both of the other genera under consideration. The shape of the paragonocoel, in anterior aspect, is also characteristic in its pronounced median expansion.

#### KEY TO THE SPECIES OF TRICHOONOSTREPTUS

1. Paragonocoel not exceeding tip of telocoxite; process A of telocoxite near the mesial margin, process B tapering gradually distad; eye patch with about 42 ocelli. .... *camerani* (Silvestri)
- Paragonocoel longer than telocoxite; process A of latter definitely removed from the mesial margin, process B strongly lobed proximad of its reduction into C; ocelli more than 50. .... 2
2. Process A of telocoxite larger, extending as far distad as B, with an acute subterminal, laterally produced spur; process B not strongly produced distolaterad. .... *ternetzi* Carl
- Process A of telocoxite smaller, less than half as long as B, not produced laterally into a long spur as above; process B with a conspicuous distal rounded lobe. .... *andinus* new species

**Trichogonostreptus andinus**, new species

Figures 1, 2

*Type specimen*.—Adult male, U. S. National Museum, from Caiza, Bolivia; collected in 1896 by Sig. Alfredo Borelli.

*Diagnosis*.—Differing from the other two known species of the genus as indicated in the foregoing key.

*Description*.—Type specimen greatly fragmented, length indeterminate, width, 6.0 mm. Number of segments, 65, the last legless.

Head: labrum distinctly set off across its entire width, smooth except for the median teeth. Labral pores elongated and open at the bottom, merging into the labral area. Clypeus with two rather large, conspicuous, paramedian pits. Frons and vertex smooth, without striae, genae smooth but for a few tiny striae, not margined laterally. Interocular space about equal in width to greatest length of an eye patch. Latter reniform-subtriangular, extending mesad as far as inner margin of antennal socket, each composed of 8 rows of hexagonal ocelli, arranged as follows, from top to bottom: 12, 12, 10, 9, 8, 6, 4, 2, total, 63. Antennae slender, reaching back to 3rd segment, 1st article glabrous, 2nd longest, about  $2\frac{1}{2}$  times as long as broad; 3rd-6th decreasing in length and becoming increasingly setose, 6th rounded-ellipsoidal, with a small terminal sensory area on the dorsal side. Four terminal sensory cones.

Collum large, smooth, with a small dorsal median impression; ends produced cephalad into elongate lobes which completely conceal the mandibles in lateral aspect.

Pleural areas of 2nd segment strongly striate, their ends separated by a distance equal to the length of 2nd antennal article. Ventral ends of pleurites of 4th segment much raised above the level of the sternite and the pleurites of adjoining segments.

Pleurotergites of thoracic and abdominal segments smooth and shining, the transverse sulcus well defined across dorsum. Many of the midbody segments with numerous small, very shallow, rounded impressions above and behind the pores. Pore series beginning on the 5th segment. Sides below pores with moderately developed lateral striae, these increasing in size ventrad, but not forming dentations along the caudal margin of the segments.

Telson very finely punctate, the distal end set off as a coriaceous, subtriangular extension, which is much exceeded by the anal valves. Latter finely punctate, with very large, somewhat swollen mesial flanges. Anal scale discrete, broadly triangular, with the free edges somewhat concave.

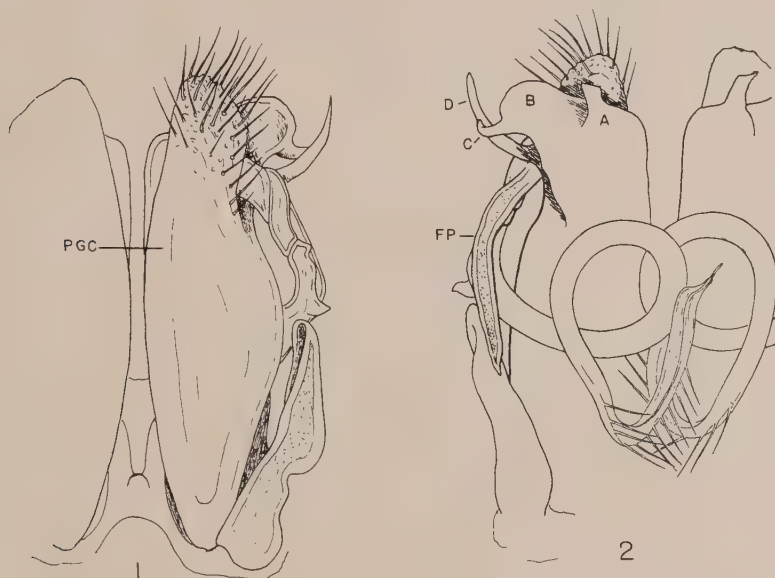
Legs long, two distal joints being visible from above the body when extended. Fourth and fifth joints with extrusible ventral pads. Legs very bristly, each of the four distalmost joints with about eight long ventral setae, and the tarsal joint with numerous smaller setae and a larger one near the claw.

First pair of legs of the usual form, the prefemora with large rectangular processes much as those illustrated for *Plenogonostreptus pectinatus* by Schubart.



Anterior gonopods of the general form as illustrated and as discussed above. The inner basal corners of the telocoxites are firmly joined by a distinct zygomatic sternite, the lateral arms of which extend caudad, becoming broader and strap-like, to fuse partially to the caudal edge of the bases of the telocoxites.

Paracoxites subtriangular, concave on their inner surface, about half as long as telocoxite, to which they attach basally by a freely movable joint. Paragonocoel continuous with telocoxite along the outer margin, elongate, slightly bent distolaterad, widest at its mid-length; distally beset with a field of long slender setae.



FIGS. 1, 2. *Trichogonostreptus andinus*, new species

Telocoxite distally bent lateral at about a 45 degree angle, its mesial margin smooth and without dentations or other modification. Immediately behind tip of paragonocoel, the telocoxite is provided with a thin, acutely triangular, caudally directed lamina, indicated in the illustration as process A. The terminal part of the telocoxite is abruptly drawn out into a distinct uncate process (B). The process corresponding to the "lateral cone" of other spirostreptoids (process D) is long, slender, and gradually curved distolaterad.

Telopodites twisted just beyond their exertion from gonocoela. Femoral process (FP) rather long and blade-like, curving around behind telocoxite parallel to the postfemoral portion of the telopodite. Latter slender, forming a complete turn on itself and becoming broader distally, its outer margin with ten to twelve long acicular spines. The seminal groove is carried out beyond the laminate portion on a tiny solenomerite.

## TRICHOGONOSTREPTUS CAMERANI (Silvestri)

*Plusioporus camerani* Silvestri, 1895, Boll. Mus. Torino, **10**(203): 10, fig. 20 (Rio Apa, Paraguay).

*Trichogonostreptus camerani* Carl, 1918, Rev. Suisse Zool. **26**: 431. Schubart, 1945, An. Acad. Brasileira Cienc. **17**: 56.

Silvestri's original description and illustration leave a great deal to the imagination, but I think it advisable for the present to assume that *camerani* is different from Carl's *ternetzi*. Dr. Schubart, in the work cited, has already remarked the possibility that the Carl name may be a junior synonym.

The original description offers little that is not merely generic in nature. From the illustration of the gonopods I have selected several differences which seem to be more than mere errors or generalizations in drawings, and have included them in the preceding tentative key for recognition of the three known species.

## TRICHOGONOSTREPTUS TERNETZI Carl

Figure 3

*Trichogonostreptus ternetzi* Carl, 1918, Rev. Suisse Zool. **26**: 429, figs. 7, 8 (San Jose, Paraguay). Schubart, 1945, An. Acad. Brasileira Cienc. **17**: 55. Attems, 1950, Ann. Naturh. Mus. Wien **57**: 203.

Originally described from Paraguay, this species has subsequently been reported from Salobra, Mato Grosso, Brasil, by Schubart (op. cit.) who observed that his single male specimen agreed in most respects with the original description, but differed in that process D of the telocoxite was somewhat larger than that figured by Carl. Attems recorded an additional collection of the species from Paraguay (without precise locality), and gave some descriptive notes on his material, extending the known range of segment variability from 59 and 60 to 65 and 66.

The accompanying illustration of this gonopod (fig. 3) is taken from Carl's original, and included here to show the close concordance in major structural points with *T. andinus*. The original lettering for the apophyses of the telocoxite has been retained and used to indicate the homologs of the two species.

**Oreastreptus**, new genus

*Type*.—*Oreastreptus sanborni*, new species.

*Diagnosis*.—Tibiotarsus of gonopod with a series of fimbriate processes along the outer margin; femoral process small, elongate, and slender, arising at a point well beyond the point of exertion; telocoxite rather massive, its inner margin with one or two large dentations along the distal third, terminating in a somewhat cristate hood-like portion which is modified laterally into two acute processes; paragonocoel shorter than telocoxite, its sides straight and nearly parallel, becoming acuminate distally and set with a small field of short, spiculi-form setae. Legs with ventral membraneous pads on two joints.

Antennae with two articles bearing sensory areas. Pore series beginning on the 6th segment.

*Distribution*.—Southern Peru.

*Remarks*.—In addition to the obvious characters of the telocoxite which distinguish *Oreastreptus* from *Trichogonostreptus*, reference may be made to an additional feature, the shape of the gonopod sternite and its mode of attachment. In the present genus the small sternite is produced distally on each side into long terminally rounded processes which are fused with the mesial edge of the telocoxites. Such processes are not conspicuous in species of *Trichogonostreptus*, and seem not to be developed. Studies now in progress will deal in detail with the comparative morphology of the gonopodal sternite in spirostreptoids.



FIG. 3. *Trichogonostreptus ternetzi* Carl.

FIG. 4. *Oreastreptus carli* (Attems).

#### OREASTREPTUS CARLI (Attems)

Figure 4

*Trichogonostreptus carli* Attems, 1950, Ann. Naturh. Mus. Wien **57**: 203, figs. 14–16 (Loandro).

For the purpose of comparison with the illustrations of *O. sanborni*, Attems' original figure of the gonopod of *carli* is here reproduced. Despite its obvious crudity, the drawing shows the generic features of *Oreastreptus* very well.

Attems gave no other locality for his material than "Loandro." I have been unable to find this place on any map, including the



"Millionth Map of Latin America" and suppose that it must represent either a very small locality or possibly a misinterpretation of a manuscript field label. The type of *carli* doubtless came from southern Peru or adjacent parts of Bolivia.

**Oreastreptus sanborni**, new species

Figures 5, 6

*Type specimen*.—Adult male, Chicago Nat. Hist. Mus., from Segrario, Dept. of Puno, Peru; collected on October 10, 1941 by Colin C. Sanborn.

*Diagnosis*.—Differing from *carli*, the only other known species, in its larger size, by the impunctate tergites, and in that the posterior lateral projection of the telocoxite is long and acute instead of short and blunt.

*Description*.—The following notes were made from the type specimen: length about 95–100 mm. (specimen broken), width, 5.8 mm. Number of segments, 61.

Head entirely smooth, frontal area not vertically striate; sides of head not margined, area below eye patches not sulcate. Ocelli about 48 in each reniform-subtriangular patch, in about 7 rows. Antennae moderately long, reaching back to front edge of 5th segment; articles becoming distally setose; 5th and 6th articles with prominent rounded subterminal sensory pits on the dorsolateral side. Four terminal sensory cones.

Collum smooth, its anterior-lateral portion produced cephaloventrad into a subtriangular blunt lobe set off by a single basal sulcus beginning at the level of the eye patch.

Pleurotergites smooth across dorsum, segmental suture very distinct; prozonites with seven or eight very fine parallel encircling striae; lateral striae of metazonites beginning just below level of pores except on the first few segments where very short striae follow the suture up almost to the middorsal line.

Pore series beginning on the 6th segment; the pores located about a third of the distance from suture to caudal edge of the segment.

Anal segment chiefly smooth except for the middorsal subtriangular projection, which is strongly wrinkled, and although more produced than usual in spirostreptoids does not exceed or conceal the valves. Latter smooth, convex at their bases but the distal margins becoming strongly compressed into wide flat narrow lips which project considerably past the rest of the anal segment. Preanal scale discrete, strongly triangular and almost as long as wide, but appearing partly fused with the caudal edge of the penultimate segment.

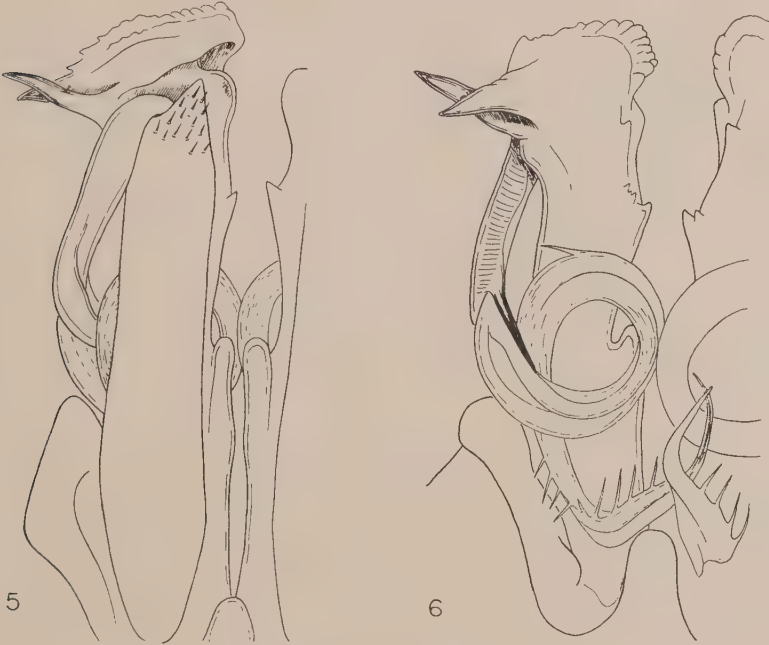
Legs stout, generously supplied with long bristles except the coxal joint; membranous pads present on the ventral sides of the 4th and 5th joints, the pads bordered by somewhat larger bristles.

Gonopods large and robust appendages of the form as shown in the figures. Sternite very distinct, with long, slender distal processes fused to the mesial edges of the telocoxites.

Paracoxites moderate in size, attached to base of telocoxites by a

freely movable joint. Paragonocoel continuous with telocoxite along the outer margin, elongate and very slender, widest near the base, terminating in a short triangular setose point.

Telocoxite becoming larger and diversified distally, with several small sharp denticles on and near the mesial margin. Distally the telocoxite is produced distinctly cephalad over the tip of the paragonocoel, forming an overhanging hood-like structure. Laterally the end of the telocoxite is drawn out into two subequal acuminate processes, of which the anteriormost is directed distolaterad, the posteriormost proximolaterad. The distal surface of this area is strongly tuberculate, rather cristate in appearance.



FIGS. 5, 6. *Oreastreptus sanborni*, new species.

Telopodites straight for a considerable distance beyond the point of exit from the gonocoel. Femoral process short, spiniform, darkly pigmented. Postfemoral portion set off by a distinct articulation, beyond which the telopodite describes a complete circle, with a small spiniform process along its outer margin. Distad of this spine the telopodite becomes very thin and hyaline, distinctly broadened, with a series of eight to ten slender filamentous processes along the outer margin. Distally this portion is drawn out into a slender tapering tip, carrying the seminal groove.

Color: prozonites white, most of the metazonite gunmetal gray, with a dark reddish-brown band on the caudal margin of each segment. Head, collum, anal valves, and legs light brown or tan in life.

## Genus PTENOGONOSTREPTUS Schubart

*Ptenogonostreptus* Schubart, 1945, An. Acad. Brasileira Cienc. **17**: 61; 1950, *Dusenía* **1**(6): 340.

*Type*.—*P. unilineatus* Schubart, by original designation.

*Diagnosis*.—Tibiotarsus of gonopod with a series of five or six filamentous processes along the outer margin; distal end of paragonocoel drawn out into an elongate, acuminate, distally curved process which does not attain tip of telocoxite; latter distally rounded, with a small subterminal projection on the mesial margin and drawn out into a triangular or elongate lateral process; telopodite with a moderately long, falcate femoral process arising just proximad of the joint and at the point of exsertion from the gonocoel. Pore series beginning on the 6th segment. Anal segment of normal form.

*Distribution*.—States of Mato Grosso, Goiás, and São Paulo, Brasil.

*Remarks*.—I have seen no material of this genus, and can not make any comments concerning the nature of the gonopod sternite, but judging from Dr. Schubart's excellent illustrations, the relationship of sternite to telocoxites appears to be much as in *Oreastreptus*. Here, also, as in that genus, the pore series begins on the 6th segment.

*Species*.—Three, a key for the separation of which appears in Dr. Schubart's 1950 paper in *Dusenía*.

## PTENOGONOSTREPTUS FALLAX Schubart

*Ptenogonostreptus fallax* Schubart, 1950, *Dusenía* **1**(6): 342, figs. 11, 12 (São Paulo, Brasil).

## PTENOGONOSTREPTUS PECTINATUS Schubart

*Ptenogonostreptus pectinatus* Schubart, 1950, *Dusenía* **1**(6): 341, figs. 9, 10 (Rio Maranhão, Mun. Uruacu, Goiás, Brasil).

## PTENOGONOSTREPTUS UNILINEATUS Schubart

*Ptenogonostreptus unilineatus* Schubart, 1945, An. Acad. Brasileira Cienc. **17**: 61, figs. 3, 4 (Barra do Tapirape, Mato Grosso, Brasil); 1947, Bol. Museu Nac., Zool. **82**: 19.

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## A New Crawfish of the Genus *Procambarus* from Arkansas (Crustacea, Astacidae)<sup>1</sup>

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The new species described here is the tenth of the *Spiculifer* group thus far described. It has been known for several years, but a description has been postponed until the number of specimens was adequate to define its variational limits.

### *Procambarus ouachitae*, sp. nov.

*Procambarus vioscae* Williams, 1954. Univ. Kans. Sci. Bull., 36 (12): 912.

*Holotype male, form I.*—Cephalothorax (figs. 1, 2) subovate, slightly wider than high (21.0–19.0 mm); abdomen same length as cephalothorax (47.0 mm). Greatest width of cephalothorax a little caudad of dorsal region of the cervical groove.

Areola relatively broad (3.7 times longer than wide) with six to seven punctations in narrowest part. Cephalic section of cephalothorax 2.6 times as long as areola; length of areola 27.6 percent of total length of the cephalothorax.

Rostrum long, excavate; sides converging to base of acumen which is set off by short lateral spines. Acumen relatively short, less than one-third as long as total length of rostrum (4.0–14.5 mm). Margins of rostrum only slightly swollen and raised. Upper surface with a well-defined carina.

Postorbital ridges prominent, grooved laterad and each terminating anteriorly in an acute, cephalolaterally-projecting spine. Branchiostegal spine strong. Two strong acute lateral spines present on each side of the cephalothorax behind the cervical groove; length of either spine of a pair less than the distance between the apices of the two spines. Upper surface of the cephalothorax with setiferous punctations; lateral surfaces finely granulate.

Cephalic section of telson with four (right) or three (left) spines in the caudolateral corners; the laterally placed spine in each case greater than twice the length of any one of the others.

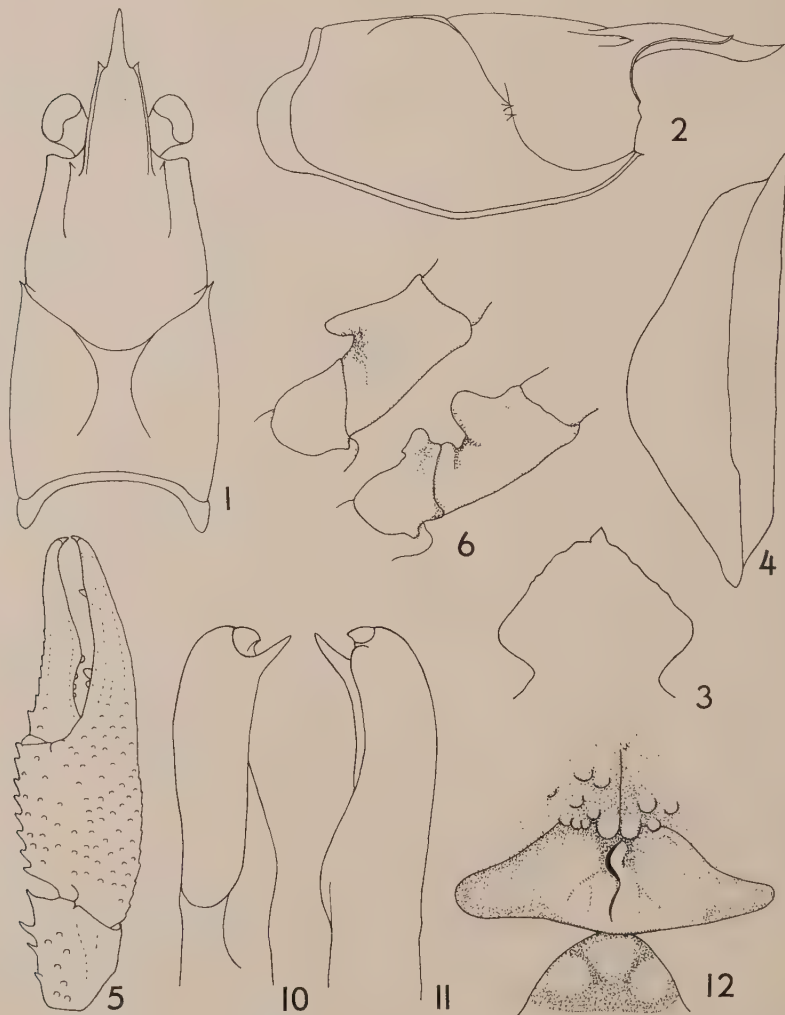
Epistoma (fig. 3) 1.76 times wider than long, with a definite cephalic point.

Antennules of usual form. Antennae broken on holotype, reaching to end of telson on other specimens. Antennal scale (fig. 4) relatively long and narrow, greatest width slightly less than one-half of the total length; total length slightly less than length of areola (12.0–13.0 mm); lateral margin terminating in a strong spine.

Chela (fig. 5) subovate, somewhat depressed, long and slender.

<sup>1</sup>This investigation was supported by grant NSF-G947 from the National Science Foundation.

Hand entirely tuberculate; inner margin of palm with a row of prominent tubercles, seven on right chela, eight on left. Opposable margin of immovable fingers with nine rounded tubercles basally and one prominent pointed tubercle distally; only the fourth rounded tubercle from the base is conspicuous; dactyl of each chela with a row of 13 rounded tubercles, of which only the fourth (right) or fifth (left) from



FIGS. 1-6, 10-12. *Procambarus ouachitae*, sp. nov. 1, 2. Cephalothorax of holotype; 3. Epistoma of holotype; 4. Antennal scale of holotype; 5. Chela and carpus of holotype; 6. Hooks of holotype; 10, 11. Mesial and lateral views of first pleopod of morphotype; 12. Annulus ventralis of allotype. Pubescence removed from all structures illustrated.

the base is large and conspicuous. Fingers meet for entire length when flexed.

Carpus (fig. 5) tuberculate on upper surface; inner surface with two strong acute spines on margin near distal end; under side with two strong acute spines on distal margin.

Inner margin of basipodite of first pereopods lacks spines; ischiodite of first pereopods with five (right) or six (left) spines.

Hooks (fig. 6) present on ischiopodites of third and fourth pereopods; hook on third pereopod long, straight and slender; hook on fourth pereopod stubby, thumblike. Basipodite of fourth pereopod with a conspicuous hook apposed to hook on ischiopodite. Coxopodites of fourth and fifth pereopods each with a conspicuous caudomesial knob.

First pleopod (figs. 7, 8, 9) reaching to middle of the coxopodite of the third pereopod when abdomen is flexed. Apex terminating in three distinct parts which as a unit extend caudad at about a  $45^\circ$  angle to the shaft of the pleopod. Mesial process spiculiform, non-corneous, extending caudodistad. Cephalic process represented by an angulate lobe at the cephalic base of the central projection. Caudal element consists of three parts: a well-defined, corneous, subacute caudal process lies caudolaterad of the central projection; a rounded, non-corneous caudal knob projects distad on the lateral surface; and, the accessory process is represented by a thin, corneous ridge caudomesad of the central projection. Central projection corneous, subacute, extending caudodistad at about a  $45^\circ$  angle to the pleopod shaft; fusion lines of its component elements clearly defined.

*Allotype female*.—Similar to holotype in general appearance; chelae greatly reduced; median carina well developed. Annulus ventralis (fig. 12) immovable, partially hidden by several caudally-projecting tuberculate prominences of the fourth sternite; transverse width about twice length; median depression flanked by lateral and caudal elevations; sinus S-shaped.

*Morphotype male, form II*.—Similar to holotype in general appearance; chelae and hooks on ischiopodites of third and fourth pereopods greatly reduced; median carina of rostrum present but not as conspicuous as on holotype. First pair of pleopods (figs. 10, 11) reaching to cephalic margin of coxopodite of third pereopod when abdomen is flexed; all processes reduced and non-corneous.

*Measurements*.—As follows, in millimeters:

	Holotype	Allotype	Morphotype
Cephalothorax:			
Length.....	47.0	44.5	36.0
Width.....	21.0	19.5	16.0
Height.....	19.0	19.0	15.0
Areola:			
Length.....	13.0	12.0	9.5
Width (at narrowest point)....	3.5	3.5	2.5
Rostrum:			
Length.....	14.5	15.0	12.5
Width at base.....	7.5	7.0	6.0



	Holotype	Allotype	Morphotype
Abdomen:			
Length (to tip of telson) . . . . .	47.0	45.5	38.0
Right chela:			
Length of outer margin of hand	45.0	25.5	20.0
Length of dactyl . . . . .	25.0	15.0	11.0
Width of palm . . . . .	13.5	8.8	6.0
Thickness of palm (greatest) . .	9.5	5.5	4.5
Length of inner margin of palm	16.0	9.0	7.0

*Type locality*.—The holotype, allotype and morphotype were collected from a tributary of the South Fork of the Saline River, 2.4 miles north of U. S. highway 70 on a local road, 6.5 miles northeast of Hot Springs city limits (or, 7.7 miles south-southwest of Owensville), Garland County, Arkansas, May 30–31, 1955, by Ernest A. Liner and the writer. At the site of collection the tributary was a small (15 to 20 feet wide), shallow (less than 24 inches deep), cool (19°C), fast-flowing, clear creek with a gravel, sand and rock bottom. Moderate amounts of aquatic vegetation (*Scirpus nana* and *Ludwigia* sp.) grew along the edges and the banks were open or brushy. Crawfish associates of the 34 *P. ouachitae* collected included 54 *Orconectes palmeri longimanus* (Faxon), 12 *Orconectes leptogonopodus* Hobbs, and 3 *Procambarus blandingii acutus* (Girard).

*Disposition of types*.—The holotype, allotype and morphotype are deposited in the United States National Museum, numbers 99222, 99223 and 99224 respectively. The paratypes are in the following collections: United States National Museum, Academy of Natural Sciences of Philadelphia, American Museum of Natural History, Carnegie Museum, personal collection of Dr. Horton H. Hobbs, Jr. at the University of Virginia, Kansas University Museum of Natural History, and Tulane University.

*Geographic distribution*.—Of the 90 specimens examined, the majority (75) were collected from the Ouachita river system in south central Arkansas within or on the periphery of the Athens Piedmont Plateau and the Novaculite Uplift of the Ouachita Province as defined by Fenneman (1938) (fig. 16). Only 15 specimens (17%) were taken at one locality in Bayou Meto, a tributary of the Arkansas River within the Mississippi River floodplain. As a species, *P. ouachitae* appears to be isolated geographically (and perhaps ecologically) from its closest relatives. Nearest locality records of these (fig. 16) are: *Procambarus vioscai* Penn (1946: 27) in tributaries of the Ouachita River in northern Louisiana; *P. natchitochae* Penn (1953: 5) in Bayou Dorcheat, a tributary of the Red River, in southern Arkansas; and, *P. dupratzi* Penn (1953: 1) in the Cossatot River, a tributary of the Red River, in southwestern Arkansas.

Locality records of the *P. ouachitae* paratypes are as follows. **OUACHITA RIVER SYSTEM.** *Clark County*: Caddo River at Arkadelphia, date unknown, D. S. Jordan and J. Z. Gilbert (USNM 9430); Terre Noire Creek, 9.8 miles east of Antioine, May 31, 1955, G. H. Penn and E. A. Liner (TU 3146); *Dallas County*: Saline River, 1 mile north of Faringdale, June 5, 1934, C. E. Burt (USNM 89131);

TABLE 1. VARIATION IN QUACHITA RIVER SPECIMENS OF *Procambarus quachitae*.

Character	HOLOTYPE	$\sigma_1$			$\delta_1$			$\delta_2$			$\delta$			$\delta^{Juv.}$			$\delta^{Juv.}$		
		RANGE	MEAN	S.D.	RANGE	MEAN	S.D.	RANGE	MEAN	S.D.	RANGE	MEAN	S.D.	RANGE	MEAN	S.D.	RANGE	MEAN	S.D.
Number of Specimens	1																		
Number of Specimens	47/0																		
Length, mm.		33.0-51.6			32.0-49.3			30.5-48.0			11.2-28.0			15.2-29.5					
Cephalothorax:																			
Length/Width	2.24	2.23-2.43	2.32	0.077	2.25-2.47	2.37	0.112	2.28-2.54	2.38	0.073	2.15-2.67	2.45	0.104	2.27-2.60	2.44	0.083			
Length/Postorbital Width	4.70	4.70-5.11	4.94	0.195	4.72-4.92	4.78	0.043	4.56-5.23	4.87	0.192	4.38-5.19	4.77	0.186	4.38-5.18	4.73	0.147			
Cephalothorax:																			
Length/Length of Rostrum	3.24	2.99-3.24	3.12	0.059	2.98-3.04	2.94	0.070	2.75-3.09	2.94	0.082	2.43-3.22	2.82	0.166	2.36-3.04	2.80	0.124			
Length/Lateral Spine Space - R	36.15	25.38-36.50	29.98	5.808	23.31-45.00	34.81	7.745	25.26-47.14	33.13	6.497	27.14-46.00	33.38	5.171	24.50-49.25	30.54	5.188			
Cephalothorax:																			
Length/Lateral Spine Space - L	36.15	27.31-36.50	32.02	4.135	26.20-45.00	34.94	7.758	24.29-43.75	31.71	5.500	27.14-39.00	30.97	5.340	24.88-52.00	30.91	5.983			
Cephalothorax:																			
Length/Length of Areola	3.62	3.42-3.79	3.64	0.059	3.59-3.79	3.73	0.091	3.47-4.12	3.79	0.165	3.46-4.67	3.97	0.250	3.08-4.24	3.98	0.134			
Cephalothorax:																			
Length/Length of Chela	1.04	0.98-1.39	1.19	0.173	1.52-1.86	1.68	0.178	1.57-2.06	1.94	0.350	1.81-2.44	2.17	0.174	2.07-3.10	2.32	0.243			
Cephalothorax:																			
Length/Length of 1st Pleopod	4.48	4.42-4.86	4.59	0.169	4.39-5.08	4.83	0.333	---	---	---	4.67-7.63	5.97	0.801	---	---	---			
Rostrum:																			
Length/Width	1.93	1.93-2.35	2.12	0.613	2.08-2.20	2.14	0.053	2.07-2.45	2.27	0.107	1.85-2.88	2.34	0.209	1.98-2.78	2.32	0.195			
Rostrum:																			
Length/Length of Rostrum	3.63	2.49-3.63	2.88	0.464	2.89-3.38	3.03	0.233	2.71-3.33	2.78	0.312	2.39-4.83	2.77	0.560	2.38-3.42	2.76	0.239			
Areola:																			
Length/Width	3.71	3.35-4.83	4.03	0.499	3.86-4.23	3.95	0.191	2.40-4.10	3.57	0.488	2.50-5.00	3.64	0.956	2.72-5.00	3.51	0.480			
Chela:																			
Length/Width of Palm	3.33	3.11-3.47	3.31	0.123	3.17-3.44	3.29	0.126	2.80-3.44	3.18	0.160	2.43-4.12	3.82	0.238	3.26-4.33	3.71	0.306			
Chela:																			
Length/Length of Dactyl	1.80	1.80-1.91	1.85	0.039	1.77-1.85	1.82	0.011	1.65-1.78	1.72	0.038	1.65-1.91	1.78	0.020	1.63-1.89	1.77	0.050			
Spines on 1st. Ischlopodite - R	5	3-6	4.90	3.27	3-5	3.76	3.66	3-5	3.66	3.66	3-5	4.29	3.66	3-5	4.29	3.66			
Spines on 1st. Ischlopodite - L	6	3-6	4.60	4.25	4-5	4.25	4.25	3-5	3.98	3.98	0-4	3.09	3.09	2-5	3.05	3.05			

*Garland County*: tributary to the Ouachita River, 0.2 miles north of Hot Springs, August 8, 1953, E. A. Liner (TU 2955); South Fork of the Saline River, 7.7 miles southsouthwest of Owensville, April 22, 1952, E. A. Lachner (USNM 99226); tributary to the South Fork of the Saline River, 6.5 miles northeast of Hot Springs, August 7, 1953, E. A. Liner (TU 2954); same locality, May 30, 1955, G. H. Penn and E. A. Liner (ANSP, MCZ, AMNH, CM, HHH, TU 3143); *Hot Spring County*: tributary to the Ouachita River, 8 miles east of Bismarck, October 6, 1947, A. B. Leonard (KUMNH 702); Sugar Loaf Creek, 9.6 miles northeast of Glenwood, May 31, 1955, G. H. Penn and E. A. Liner (TU 3148); Fourche A'Loupe Creek, 8 miles northwest of Bismarck, June 1, 1955, G. H. Penn and E. A. Liner (TU 3149); *Nevada County*: Moore's Creek, 4.4 miles northwest of Prescott, June 1, 1955, G. H. Penn and E. A. Liner (TU 3152); *Pike County*: Antoine Creek at Antoine, date unknown, W. P. Hay (USNM 22515); same locality, August 8, 1953, E. A. Liner (TU 2958); Antoine Creek, 2.5 miles north of Kirby, April 21, 1952, E. A. Lachner (USNM 99225); tributary to Antoine Creek, 1.6 miles east of Delight, May 31, 1955, G. H. Penn and E. A. Liner (TU 3147); *Saline County*: Saline River, 2 miles west of Benton, September 3, 1955, R. D. Suttkus (TU 3353). **ARKANSAS RIVER SYSTEM.** *Arkansas County*: Bayou Meto, 2 miles north of Humphrey, March 23, 1951, C. Gillette and T. Tucker (TU 2340).

*Color*.—The color pattern of *P. ouachitae* (fig. 17) immediately distinguishes it from any of the other species of the *Spiculifer* group. Color designations in the following description are those of Maerz and Paul (1950) and were made on freshly killed mature paratypes from the type locality. Mid-dorsal part of the cephalothorax and abdomen light olive green speckled with dark olive green punctations; this area is flanked laterally by a pair of irregularly-margined dark olive green stripes. Ventrolaterad of each stripe is a narrower strip of creamy-white color. The ventral half of the lateral aspect of the cephalothorax is of an homogeneous light smoke-brown color. The upper surfaces of the chelae are peach-biege background with the keel on the outer margin of the hand and the tubercles of the palm blue-black. The fingers are solid blue-black except for the apical fourth which is mandarin-orange. Other markings are shown in the figure.

*Ecological and life history notes*.—An analysis of habitat data for twelve collections yields the following. *P. ouachitae* occurs in creeks (100%) where there is a strong current (91%), and in which the water is clear (83%), colorless (100%), shallow, *i.e.*, less than 15 inches deep (55%), exposed to sunlight (54%), and with bottoms of gravel and sand, or gravel and sand combined with flat rocks (91%). Aquatic vegetation was sparse to moderate in abundance (63%) and included *Scirpus nana*, *Dianthera americana* and *Ludwigia* sp. Water temperatures recorded in late May and early June ranged between 19 and 21°C.

#### EXPLANATION OF FIGURES 7-9, 13-15

FIGS. 7-9, 13-15. *Procambarus ouachitae*, sp. nov. 7, 8, 9. Mesial, caudal and lateral views of first pleopod of holotype; 13, 14, 15. Mesial, caudal and lateral views of the first pleopod of a variant paratype from the type locality. Pubescence removed from all structures illustrated.





7



8



9



13



14



15

*P. ouachitae* is primarily a nocturnal species, hence the accumulation of large samples from many localities has been difficult to achieve. At the type locality, however, night collecting was possible and the largest sample was obtained. Collecting by dip net the following morning at the same locality yielded only one mature specimen (a female) and a few juveniles, all of which had to be dislodged from the aquatic vegetation, debris and roots at the edge of the stream. Most of the larger individuals of both sexes hide in burrows that they dig in the banks. The openings of these are at or slightly above normal water level, and are usually well concealed by overhanging roots and vegetation. Individuals of all sizes were observed foraging at night in the relatively quiet water near the stream banks, whereas their

TABLE 2. VARIATION IN BAYOU METO SPECIMENS OF *Procambarus quachitae*.

Character	♂ Juv.				♀ Juv.			
	RANGE	MEAN	S.D.		RANGE	MEAN	S.D.	
Number of Specimens		6				8		1
Cephalothorax Length, mm.	16.9 - 30.0				14.9 - 26.0			
Cephalothorax:								
Length/Width	2.43- 2.58	2.52	0.054		2.29- 2.72	2.45	0.109	2.75
Cephalothorax:								
Length/Postorbital Width	4.54- 5.00	4.70	0.163		4.36- 4.97	4.64	0.132	4.70
Cephalothorax:								
Length/Length of Rostrum	2.61- 2.81	2.67	0.072		2.53- 2.69	2.64	0.061	2.95
Cephalothorax:								
Length/Lateral Spine Space - R	29.14-33.80	31.13	2.126		26.00-36.60	30.76	3.529	37.00
Cephalothorax:								
Length/Lateral Spine Space - L	31.00-35.00	32.74	1.710		26.71-35.50	30.68	2.889	30.83
Cephalothorax:								
Length/Length of Areola	3.61- 4.04	3.83	0.137		3.42- 4.03	3.80	0.169	3.47
Cephalothorax:								
Length/Length of Chela	2.26- 2.35	2.32	0.052		2.09- 2.42	2.30	0.104	1.18
Cephalothorax:								
Length/Length of 1st. Pleopod	5.36- 9.05	6.84	0.942		---	---	---	4.34
Rostrum:								
Length/Width	2.33- 2.80	2.68	0.179		2.51- 2.80	2.65	0.094	2.51
Rostrum:								
Length/Length of Acumen	2.35- 2.80	2.52	0.154		2.43- 2.61	2.51	0.068	2.51
Areola:								
Length/Width	3.67- 4.80	4.22	0.543		3.92- 4.63	4.35	0.241	4.57
Chela:								
Length/Width of Palm	3.82- 4.04	3.92	0.111		3.48- 4.18	3.84	0.230	3.36
Chela:								
Length/Length of Dactyl	1.65- 1.70	1.68	0.026		1.69- 1.78	1.72	0.031	1.75
Spines on 1st. Ischiopodite - R	4 - 7	5.33	-		2 - 4	3.38	-	4
Spines on 1st. Ischiopodite - L	4 - 5	4.33	-		2 - 5	3.50	-	4

cohabitants *Orconectes longimanus* and *O. leptogonopodus* were observed foraging in all parts of the stream.

During the day all juvenile *P. ouachitae* thrown back into the water immediately darted toward the banks of the stream where the water was relatively quiet and shallow; on the other hand, *O. longimanus* darted immediately into the deep water in the center of the stream where the current was stronger.

The collections include specimens taken in April, May, June, August and September only. Form I males were found in May and August; form II males in April, May and August; and an ovigerous female (carrying 50 eggs) in September. One of the other eighteen mature females had a sperm plug in its annulus in June. Smallest juveniles (10 to 20 mm cephalothorax length) were found in May and June only.

*Variation.*—The degree of development of the cephalic process of

form I and II males shows the greatest variability of any of the characters studied. Four of the six form I males (all from the type locality, and including the holotype) are alike in having the cephalic process reduced (figs. 7, 8, 9). The other two have the cephalic process produced into a point on the medial face of the pleopod (fig. 13, 14, 15), as is also the case with three of the five form II males. None of the juvenile males shows such a development of the cephalic process.

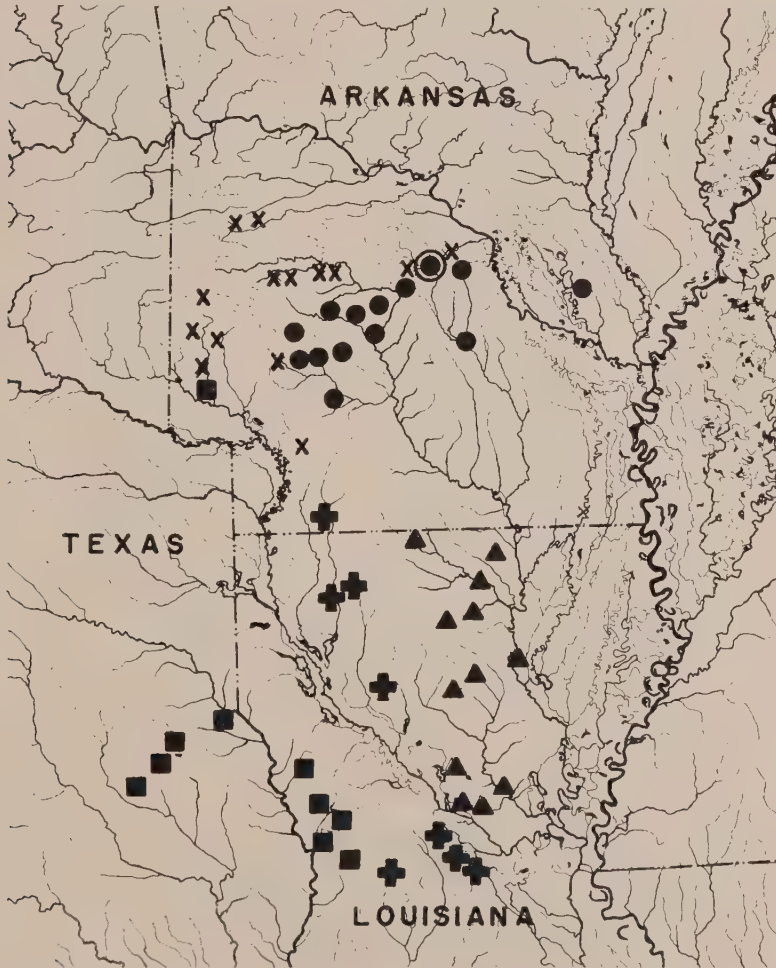


FIG. 16. Distribution of *Procamburus ouachitae* (dots) compared with the nearest known localities of *P. dupratzi* (solid squares), *P. natchitochae* (crosses) and *P. vioscai* (solid triangles), and localities which were negative for *Spiculifer* group crayfishes (X's). Locality records for *dupratzi*, *natchitochae* and *vioscai* from Penn (1953, 1956).



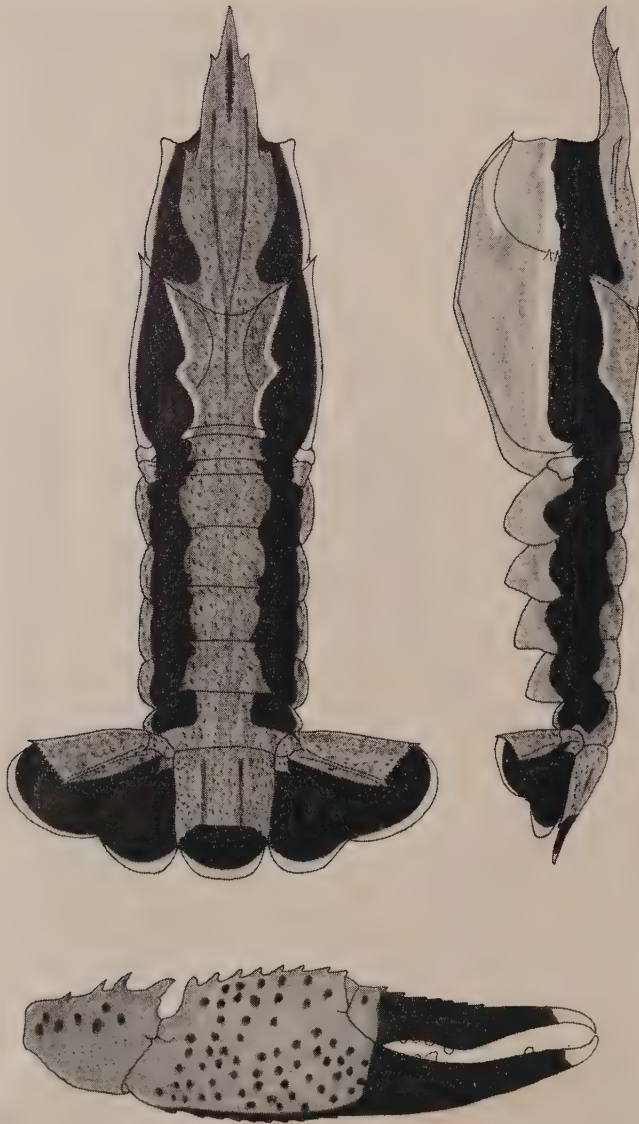


FIG. 17. Color pattern of *Procambarus ouachitae* from type locality.

Exclusive of sexual dimorphism and ontogenetic changes, body ratios and spine counts (Tables 1, 2) show the greatest variability in the length and width of the rostrum, width of the areola, and number of spines on the ischiopodites of the first pereopods. The rostrum is slightly longer and relatively narrower, and the areola slightly narrower in the specimens from Bayou Meto. The number of spines on the ischiopodites varies from zero (1 specimen only) to seven (1 specimen only), but the majority of the counts fall with a range of 3 to 5. Variation between right and left sides is the rule in most individuals, with the number of spines on the left usually greater than on the right.

In a comparison of Ouachita river system specimens with those from Bayou Meto the variation in the degree of development of the median carina of the rostrum is marked. The majority of Ouachita river system specimens (81%) have a well-developed carina, few (11%) have a weakly-developed carina, and fewer (8%) lack a carina. These latter are all juveniles (1 male, 5 females). On the other hand, the majority of the Bayou Meto specimens (67%) lack a carina, and none has a well-developed carina.

Sexual dimorphism is found in the length of the chela which is longest in form I and II males and shortest in mature females and juveniles of both sexes. Ontogenetic variation is found among males in the length of the first pleopod which is longest in form I and II males and shortest in juveniles; and, in the width of the palm which is greatest in mature specimens of both sexes, least in juveniles.

Color pattern (fig. 17) of all specimens seen alive showed some variation, but in each case the specimen in hand was distinctly different in this respect from any other species of the *Spiculifer* group.

*Relationships.*—The reduction of the cephalic process of the first pleopod of the males is suggestive of the similar reduction found in the far eastern members of the *Spiculifer* group, viz. *P. spiculifer* (LeConte, 1856: 401) and *P. raneyi* Hobbs (1953: 412). However, unless *P. ouachitae* is a relict form of an ancient pre-Pleistocene piedmont stock (which I doubt), its closest relatives should be found among those Coastal Plain species geographically located nearby. Of the three available, *vioscai*, *natchitochae* and *dupratzi* (fig. 16), the latter appears to most closely resemble *P. ouachitae*, although certainly all three are closely related and are probably descendants from a common stock.

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# Studies in Autotetraploids of Linseed (*Linum usitatissimum* L.). I. Growth Rate

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## INTRODUCTION

Among the physiological changes brought about by induced polyploidy, retardation of growth and branching and delay in flowering are widely noticed as being the most remarkable ones (Blakeslee, 1941). However, in a few cases like *Petunia* (Kostoff and Kendall, 1931) it was shown that the tetraploid grew more rapidly and flowered earlier than its diploid.

Although much work has been done on natural and artificially induced polyploids (Müntzing, 1936; Randolph, 1941; Parthasarathy, 1953), comparative study of the effects of induced polyploidy on the physiology of distinct geographical ecotypes of the same species may still have some interesting possibilities. One such species having two different ecotypes is *Linum usitatissimum* with linseed (oil) and flax (fibre) forms. Some work on the tetraploid forms of local linseed and flax varieties has been done in the temperate climates of Canada and Sweden (Ross and Boyes, 1946; Levan, 1942).

A comparative study of a few indigenous diploid varieties and their induced autotetraploids in linseed was undertaken under tropical Indian conditions to find out if there was any difference in response to tetraploidy when compared with the available results obtained with the same species in temperate climates.

## MATERIAL AND METHODS

Colchicine-induced polyploidy was produced in six different diploid, rust resistant and superior strains of linseed, *Linum usitatissimum* L., (Nos. RR10, RR39, RR52, RR63, RR68, and RR202) evolved at Indian Agricultural Research Institute, New Delhi. The seeds set on the tetraploid branches of plants of the  $C_1$  generation were used for growing  $C_2$  lines. The present study includes the observations on tetraploids of the types RR39, RR63 and RR68 only.

Five pots containing 5 seeds each were sown with each of the three tetraploids and their respective diploid controls in late October. As far as possible, identical soil, moisture, and light conditions were maintained for all pots. In a few pots where all seeds sown did not germinate seedlings from the field sown at the same time were transplanted to make up for the deficiency. Tetraploid plants were tested for their stomatal size and were later confirmed to be polyploids by the study of their pollen size and fertility. Of the 5 plants in each pot, two were marked for growth measurements. All growth measurements were taken fortnightly from the point of cotyledonary leaves, denoted here as the 0 (zero)-node. Height of plants was measured



from the 0-node to the top of the apical vegetative bud. Rate of increase in thickness of stem was recorded by the measurement of diameter at 0-node by means of a pair of calipers. For determining increase in number of branches only those arising from the head of 0-node were taken into consideration as nearly all branches emerge at this node.

#### OBSERVATIONS

##### Germination

(1) *Percentage of germination*.—Among the diploids RR39 has the highest germination percentage followed by RR63 and RR68, respectively. The germination percentage is the same in tetraploid RR63

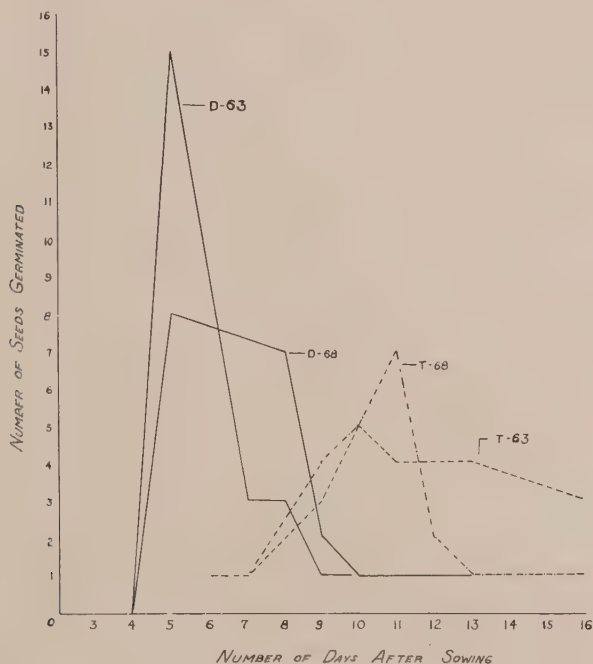


FIG. 1. Rate of seed germination in diploids and tetraploids.

but is lower in RR68 and RR39 when compared to their respective diploids (Table 1). RR39 shows a peculiar germination behavior; while the diploids give the highest percentage of germination (96%) tetraploids are extremely poor in this respect (21%). The obvious reason for such an abnormally low percentage of germination in tetraploid RR39 seems to be the abortive and undeveloped embryo in the seed.

(2) *Rate of germination*.—There is a marked difference in the rate of germination in diploids and tetraploids. Germination in tetraploids was slow and irregular, many seeds requiring more than 12 days to germinate. In diploids maximum germination took place between 5

and 8 days whereas in tetraploids most of the seeds germinated between 9 and 13 days after sowing (Table 1 and Fig. 1).

Among tetraploids, a few seedlings showed such malformations as

TABLE 1. *Rate of germination in diploids and their autotetraploids.*

Days after sowing	Number of Seeds Germinated					
	RR39		RR63		RR68	
	Dip.	Tetr.	Dip.	Tetr.	Dip.	Tetr.
5	18	—	15	—	8	—
6	5	—	—	1	—	—
7	—	—	3	1	—	1
8	—	—	3	2	7	—
9	—	—	1	3	2	4
10	—	—	1	5	1	5
11	—	—	—	4	1	7
12	—	2	—	—	1	2
13	1	—	—	4	1	1
14	—	—	—	—	—	—
15	—	—	—	—	—	—
16	—	1	—	3	—	1
Total	24	3	23	23	21	21
Seeds Sown	25	25	25	25	25	29
Germ. % age	96	12	92	92	84	72

TABLE 2. *Appearance of the first leaf in diploids and tetraploids.*

No. of days taken after sowing	Number of Seedlings					
	RR39		RR63		RR68	
	Dip.	Tetr.	Dip.	Tetr.	Dip.	Tetr.
17	12	—	13	9	3	4
18	7	—	2	—	6	2
19	2	—	2	—	5	7
20	1	—	4	4	3	3
21	2	—	2	2	4	5
22	—	—	—	4	—	—
23	—	2	—	4	—	—
24	—	—	—	—	—	—
25	—	—	—	—	—	—
26	—	—	—	—	—	—
27	—	—	—	—	—	—
28	—	—	—	—	—	—
29	—	1	—	—	—	—
Total	24	3	23	23	21	21

having one or three cotyledons, but generally there were only two cotyledons. One of these plants gave rise to fasciated shoots.

(3) *Size of cotyledons*.—The following table shows that the size of the cotyledonary leaves in tetraploids is bigger than that in diploids. They were also generally greener and more leathery in tetraploids than those in diploids.

*Size of the cotyledonary leaves in millimeters.  
The data represent the average of 10 seedlings in each case.*

Type	Size of the Cotyledonary Leaves			
	Diploids		Tetraploids	
RR39	(7.0 x 4.0)	(6.5 x 3.8)	(8.0 x 4.5)	(7.0 x 4.5)
RR63	(7.5 x 5.0)	(7.5 x 5.0)	(8.0 x 5.3)	(7.5 x 4.5)
RR68	(7.0 x 4.5)	(7.0 x 4.5)	(8.0 x 5.0)	(8.0 x 5.3)

(4) *Appearance of the first leaf*.—Table 2 shows that there is no significant difference between diploids and tetraploids in the time taken for the appearance of the first leaf. However, there is a slight tendency of delay in tetraploids.

#### Growth Studies

A general measure of growth is the rate of elongation of stem but sometimes other characters like rate of tillering or branching, increase in the thickness of stem, and length of time from sowing to flowering, etc. are also taken into consideration in studying the growth behavior.

(1) *Elongation of the stem*.—In linseed elongation of stem gives a fairly good idea of growth. Table 3 shows the increase in length of stem measured fortnightly from about two weeks after sowing practically to the end of the growing season. In the first fortnight after sowing stems showed little increase in height both in diploids and tetraploids. During this period plants established themselves firmly, increased in stem thickness but remained stunted in growth. After this period of slow growth tetraploids RR39 and RR63 showed a distinctly higher rate of growth in comparison to their respective diploids till the end of the growing phase. In RR68, however, tetraploids exceeded diploids in rate of growth only after flowering (Fig. 2).

The maximum growth period coincided in the case of tetraploid and diploid RR39, both showing greatest increase during the latter half of January. In RR63, tetraploids reached the maximum rate of growth about a fortnight earlier than did diploids, whereas in RR68, it was slightly later than in its diploid. While in tetraploids, RR39 and RR63, a high rate of growth continued for 2½ months to 3 months, the respective diploids showed a much higher rate of growth during the latter half of January. The RR68 showed a well distributed rate of growth both in diploid as well as tetraploid. The growth period was longer in all tetraploids than in their respective diploids (Fig. 2).

(2) *Rate of Branching*.—The total number of branches was significantly higher in tetraploids than in diploids (Table 4). However, it must be emphasized that till the onset of flowering the number of branches in tetraploids was either equal, as in RR39, or only slightly greater, as in RR63 and RR68, than those in the respective diploids. This considerable increase in total number of branches in tetraploids



was mainly due to the secondary flush of branching which ensued with the onset of flowering (Fig. 3). These secondary branches have no economic value, as they come up late in the season and affect adversely the crop by drawing nutrition from the plants, without adding to the production of seed.

There seems to exist an inverse correlation between the rates of increase in height of stem and number of branches in both diploids and tetraploids. The maximum growth period of stems always coin-

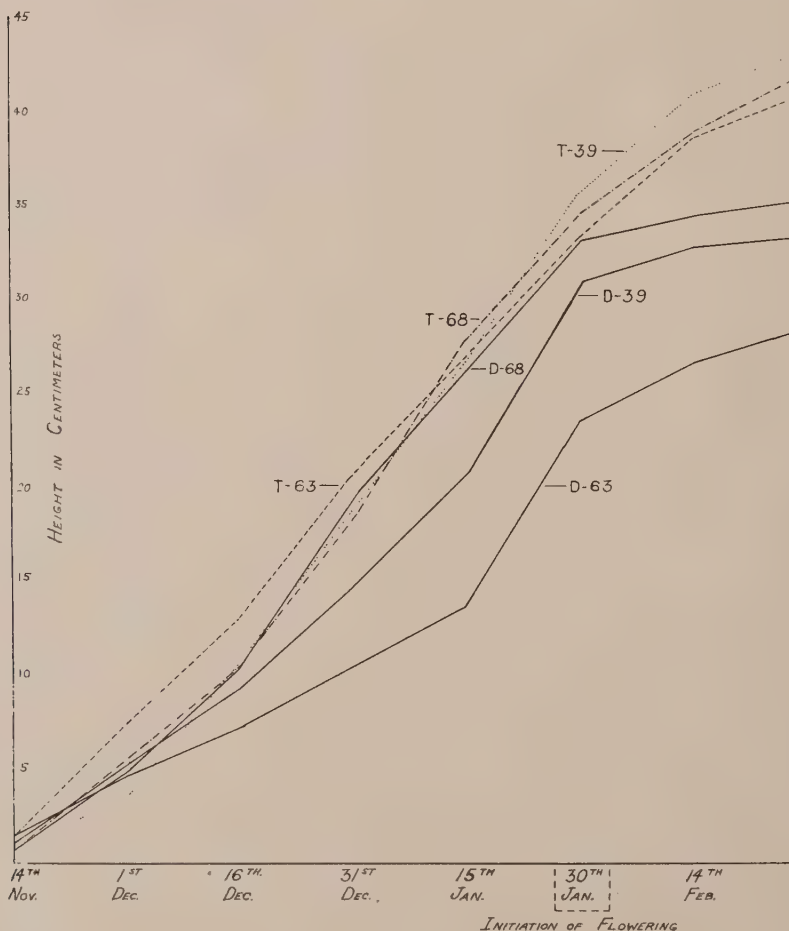


FIG. 2. Rate of stem growth in diploids and tetraploids.

cided with the least increase in number of branches. Thus in tetraploids RR63 and RR68, maximum increase in stem length occurred in the latter half of December and the first half of January, respectively, and these periods showed a very decreased rate of branching (Tables 3 & 4).

(3) *Periods between sowing and flowering*.—There is no marked difference between diploids and tetraploids regarding the period between sowing and flowering, as is evident from the following table:—

Types	Number of days taken for flowering	
	Diploid	Tetraploid
RR39	86.0	89.3
RR63	93.0	93.0
RR68	80.4	83.2

The observations on flowering and growth of stem show that by the time diploids came to flower their maximum vegetative growth period was finished and that after the onset of flowering the rate of

TABLE 3.—*Comparative rate of stem growth (in centimeters) in diploids and tetraploids.*

Type	16th. Nov.	1st. Dec.	16th. Dec.	31st. Dec.	15th. Jan.	30th. Jan.	14th. Feb.	28th. Feb.
RR39								
D	1.0	4.2	4.1	5.3	5.9	10.0	2.0	0.6
T	0.1	3.6	7.0	7.7	8.0	8.9	5.3	2.2
RR63								
D	1.3	3.3	2.5	3.3	3.3	9.6	3.1	1.6
T	1.3	6.1	5.7	7.5	6.2	6.2	5.3	2.2
RR68								
D	0.8	4.2	5.6	8.3	7.3	6.6	1.4	0.8
T	0.7	4.8	5.0	8.0	9.1	6.6	4.4	2.9

TABLE 4.—*Comparative increase in the number of branches in diploids and tetraploids during different periods of growth.*

Type	16th. Nov.	1st. Dec.	16th. Dec.	31st. Dec.	15th. Jan.	31st. Jan.	14th. Feb.	28th. Feb.
RR39								
D	0.1	1.3	1.7	0.4	1.6	0.5	0.0	0.1
T	0.0	1.7	1.3	0.0	0.3	1.6	0.7	0.1
RR63								
D	1.2	0.2	1.4	0.9	1.2	0.8	0.1	0.0
T	0.6	1.3	1.8	0.4	1.4	2.1	0.8	0.1
RR68								
D	0.2	1.7	2.0	0.4	1.3	0.8	0.1	0.0
T	1.5	1.5	1.3	1.0	0.6	2.2	0.5	0.0

elongation of stem was very retarded. In tetraploids, on the other hand, growth continued to a much later stage although with continuously retarded rate. It is because of this prolongation of vegetative growth during the blossoming period that the ultimate height in tetraploids reached a distinctly higher level than in diploids. This extended period of growth and secondary branching is also responsible for prolonging the life of tetraploid plants by a few weeks.

(4) *Increase in diameter of stem at 0-node*.—Diploids as well as tetraploids increased rapidly in diameter at 0-node during the first fortnight after sowing (Table 5). Throughout the growing period tetraploids generally showed a somewhat higher rate of increase than did diploids. Maximum increase in thickness of stem, as well as in height of stem and number of branches occurred during the fortnight preceeding flowering.

#### DISCUSSION

A comparative study of growth in three native varieties of diploid and induced autotetraploid linseed, *Linum usitatissimum*, was carried out under tropical Indian conditions. Tetraploid linseed showed slow and irregular germination. This is true of most tetraploids, although exceptions also occurred. Thus, Hesse (1938) found that the rate and percentage of germination in tetraploid *Petunia* were equal to or higher than in diploid.

Tetraploid linseed like other induced tetraploids has a longer

TABLE 5.—Rate of increase (in millimeters) in the diameter at 0-node in diploids and tetraploids.

Types		16th. Nov.	1st. Dec.	16th. Dec.	31st. Dec.	15th. Jan.	31st. Jan.	14th. Feb.	28th. Feb.
RR39	D	1.50	0.07	0.05	0.49	0.77	1.30	0.30	0.13
	T	0.80	0.50	0.10	0.93	0.50	1.83	0.80	0.50
RR63	D	1.32	0.03	0.24	0.44	1.30	0.70	0.20	0.10
	T	1.40	0.30	0.44	1.17	0.65	0.60	0.40	0.20
RR68	D	1.27	0.01	0.33	0.63	0.40	0.88	0.20	0.00
	T	1.30	0.13	0.43	0.41	1.03	1.16	0.80	0.50

growing period than diploid. However, in contrast to other tetraploids it has a higher rate of growth in different vegetative parts of the plants. The higher rate of growth coupled with the prolonged growth phase helps to attain conspicuous gigas features in tetraploid linseed. Kostoff and Kendall (1931) also reported increased rate of growth in tetraploid *Petunia*. There is practically very little difference between diploid and tetraploid linseed regarding the time taken between sowing and initiation of flowering. However, unlike in diploids, the overlapping of growth and reproductive phases in tetraploids adversely affected the seed setting and yielding capacities. Such continued vegetative growth delayed maturity of the crop, wasting considerable food material in the futile production of more shoots and increase in height, etc. which could not be utilized by the plant for greater production of flowers, fruits and seeds, because of the onset of hot and dry weather. The secondary shoots produced, if at all, only a few empty balls. However, earlier sowing of tetraploids may result in higher production of seeds.

The rate of stem growth in tetraploid linseed was higher than in diploid and the difference in height became very prominent after flowering. Levan (1942) reported lower rate of growth and dwarf



sized plants in tetraploid flax, but in tetraploid linseed he observed a higher rate of growth at the end of the season, thus leading usually to bigger plants than in diploid. Tetraploid linseed maintained a slightly higher level of increase in thickness of stem as compared to diploid. On the contrary, Levan (1942) observed a slower rate of stem thickening in tetraploid flax.

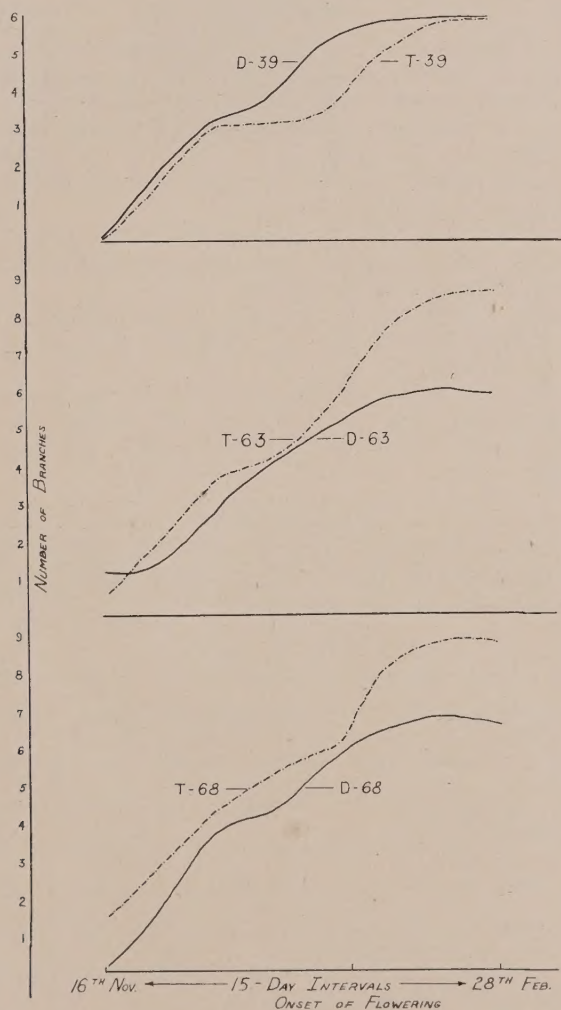


FIG. 3. Rate of branching in diploids and tetraploids.

Tetraploids have generally a lower number of branches than diploids (Hesse, 1938). However, the total number of branches at the end of the season in tetraploid linseed—RR63 and RR68—is higher than in diploid. This is mainly due to secondary branching which ensued after the onset of flowering. On the other hand, Kuhk (1943) reported

fewer branches in tetraploid flax. Onset of secondary branching followed by secondary flush of flowering towards the end of the growing season in linseed may be the result of a weak tendency to perennial habit. From extensive cytological evidence, Müntzing (1936), Tischler (1937), and Stebbins (1938) concluded that, in general, perennial forms have arisen from annuals by polyploidy.

#### CONCLUSIONS

As most of the work done abroad on *Linum usitatissimum* concerned only flax types, it is interesting to note the following important differences between tetraploids of the oil (linseed) and flax types. The differences in response to tetraploidy in linseed under different climatic conditions are also given.

(1) Tetraploid linseed is giant in form whereas tetraploid flax is smaller than its corresponding diploid.

(2) Tetraploid linseed has a greater rate of growth with respect to height of plant and thickness of stem than does diploid but tetraploid flax is slower in growth than its diploid.

(3) Number of branches and rate of branching are generally higher in tetraploid linseed than in tetraploid flax, as compared to their respective diploids.

(4) In the temperate climate of Sweden the growth rate in tetraploid linseed exceeded that in diploid only toward the end of the season whereas under tropical Indian conditions it was faster throughout the growing season.

#### ACKNOWLEDGEMENTS

I am indebted to Dr. N. Parthasarathy, Director, Central Rice Research Institute, Cuttack, for guidance and helpful criticisms during the progress of this work and to Dr. B. P. Pal, Director, Indian Agricultural Research Institute, New Delhi, for facilities and encouragement.

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